ENGINEERING

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Wind-tunnel studies

Computer that learns

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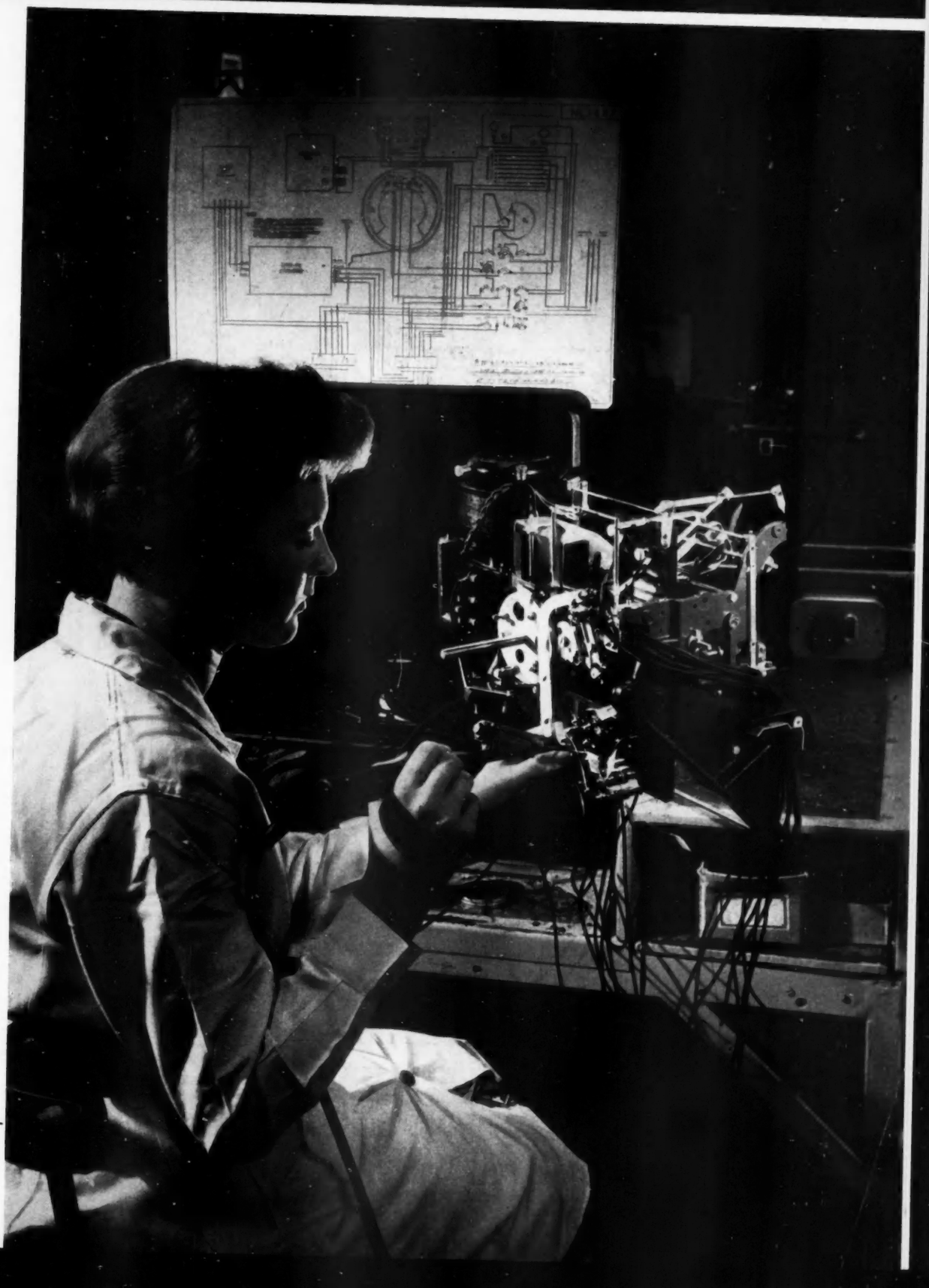

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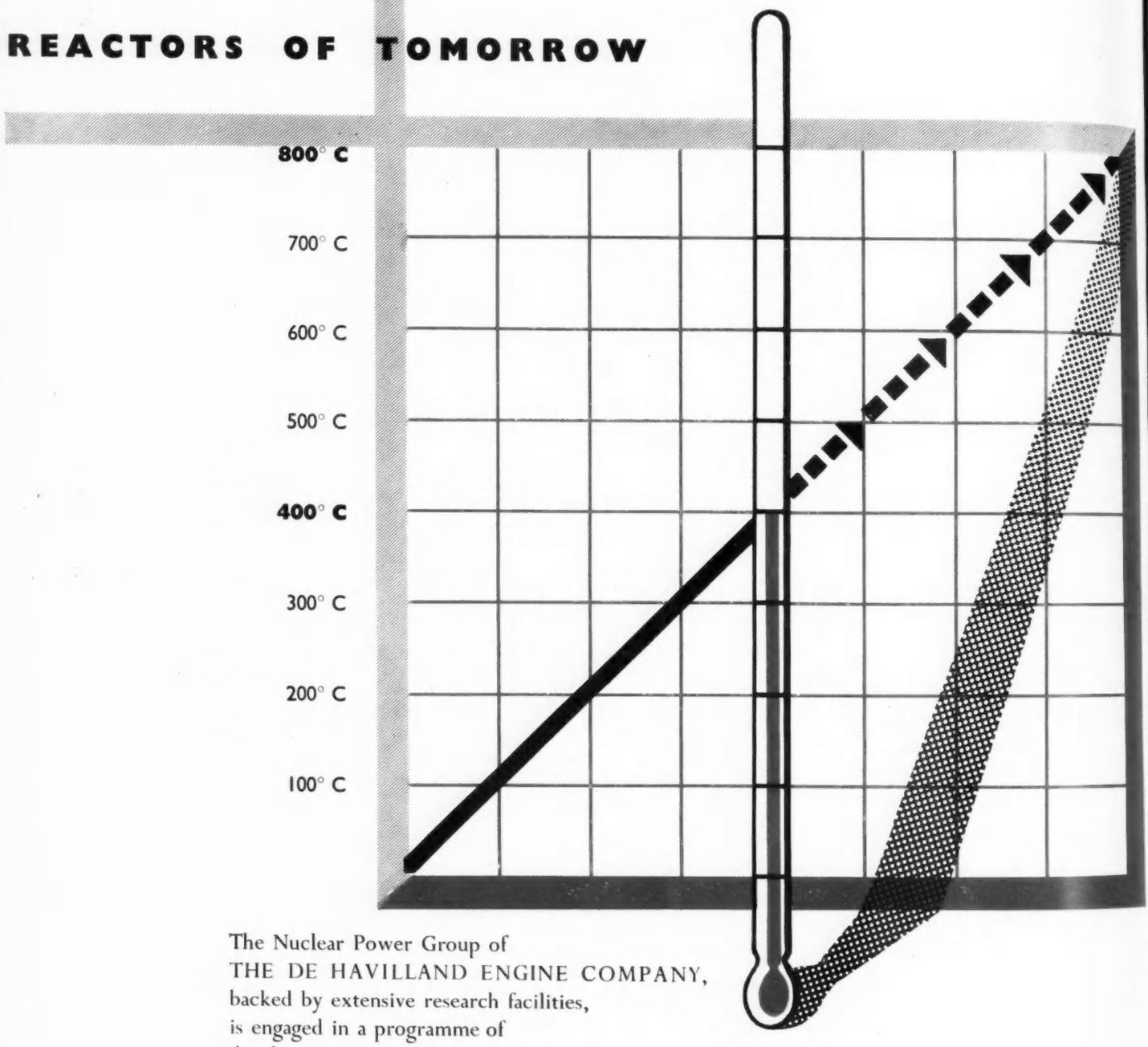

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ENGINEERING
PUBLISHED EVERY FRIDAY
Vol. 185 No. 4812 30 May 1958

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German Fare

THE annual German Industries Fair at Hanover is an impressive affair even to a visitor who has had a quick glance at the Brussels Universal Exhibition. It is impressive in spite of the absence of some principal German industries.

Whatever the wisdom of bringing together exhibitors of so many different trades, in contrast to the British decision to discontinue the practice, the combination of a trade fair and an engineering exhibition is somewhat difficult to understand. In the middle between two halls (one is almost inclined to say temples) housing technical exhibits of the great electrical engineering houses of Germany, there was a multi-storey edifice in modern concrete design. The whole edifice contained nothing but lamps and chandeliers. Two or three chandeliers make an acceptable curiosity; a whole ceiling full of them is a little harsh; but four storeys each with innumerable ceilings full of chandeliers is something approaching a nightmare. It must be supposed that they can sell a lot of chandeliers, but at least one engineer regretted that the presence of chandelier merchants made it necessary for him to be housed 30 miles from Hanover.

Nevertheless, it was a great display of engineering. An observer familiar with British exhibitions, trade for trade, could find trends worth noting. In the hydraulics hall, both liquid pumping machinery and modern high-pressure hydraulic equipment as a source of power and control were assembled. There were small water supply units designed for a single-family house and consisting of a pump, reservoir and purifier. Several manufacturers exhibited telescopic hydraulic rams, whose stroke exceeded several times their compressed length. One exhibitor claimed a device by which continuous equal extension of each telescopic link was ensured.

Perhaps of greatest interest to engineers was the transmission equipment hall. Most exhibitors were concerned with classical forms of gears, couplings, clutches and the many accessories for mechanical power transmission. However, the joy of novelty was perhaps more noticeable for the very reason that so much in power transmission has become traditional. A favoured playground for ingenuity is the infinitely-variable speed reducer. Perhaps two dozen different designs were shown. No new principle was apparent, but efficiency, reliability and adequate power are needed in these devices rather than new principles. Another trend increasingly evident in recent years is the further diversification in the variety of flexible couplings. Here again, nothing strikingly appealing to the sense of ingenuity was noticed, but many different forms of the use of both metal and rubber springs were apparent. It seems that the specialist flexible-coupling maker is now more readily accepted even by the constructor of heavy machinery, who previously thought that he alone could deal with the trying conditions of his particular service. There is an increasing use, too, of the elastic deformation of metal for the purposes of clamping, securing and generally eliminating clearances. A variety of elements, most of them not new to this exhibition, but nevertheless of recent vintage, are gaining prominence; shrink, press and sliding fits are achieved without the close tolerances and assembly gear otherwise required.

German factory equipment in the field of heating and ventilating for general and special purposes (such as spraying and treatment) revealed an industry that is extremely alive to technical development—and styling—when compared with those of other European countries. Mechanical handling equipment, however, was half-hearted. In the jig and tool hall there was quite a sprinkling of novel ideas—every exhibition in this field has its array of improved tool holders, adjustable reamers, adjustable spanners, assembly tools such as bearing extractors, and others. A wide variety of standard accessories for dial gauges was noticeable and some gauges had permanent magnet backs. At least two firms put forward the advantages of Belleville washers in place of coil springs.

Heavy electrical engineering was dominated by the big firms, each covering practically the whole field of electrical power engineering and electrical communications as well as the domestic field. The great advances made by the French electrical industry in 400 kV transmission were displayed. Small and large companies showed numerous designs of motors with built-in brakes. The neatest is the tapered air gap design which requires no separate brake magnet. In the electronics section, German industry showed as comprehensive a range of equipment as any.

The overriding impression of the Hanover Fair is that of an extremely well organised show, housed in a fair ground specifically built for its purpose. There appears to be no overcrowding. The standard of salesmanship is high, and one can expect competent information and advice at the exhibition stands. There is every evidence of forward-looking and rapidly developing industries, with a readiness for advance and experimentation which cannot fail to impress an engineer.

Cover Picture: *The mechanism of a potentiometric recording instrument is being wired before final assembly and calibration.* (*Nurnberg photograph for* ENGINEERING.)

* * *

Plain Words

On a fine morning in early summer who does not feel the old wanderlust returning to his body and soul? It caught me a few days ago in—of all places—Mayfair. I had been to the preview of a new film which has been produced for the P. & O. Company to help them to recruit young engineers for service in their fleet. In twenty-five minutes we had been in the engine-room of a liner, attending a ship's dance with the passengers, sight-seeing in Naples and Pompeii, having an interview with the company's superintendent engineer in their City of London offices, donning white tropical uniform, and looking out over the sea, where a man is not pestered by the unceasing futilities of factory and town.

In most branches of engineering you have to be content with a fairly static life, relieved only by an occasional visit to a distant conference or exhibition. With a firm of civil engineering consultants or contractors, there is always the chance of a tour abroad, but apart from this and a few other exceptions most engineers have limited scope for travel. I could well understand why the young engineer who was the principal character in the film, after he had completed an apprenticeship in heavy engineering, turned to a career as an engineer officer in the Merchant Navy.

The living conditions and amenities generally are excellent—far better than he could have hoped for by staying on land—and there must certainly be the pleasant prospect of being able to apply one's engineering training almost immediately to a specific and exciting task. The only thing that would worry me would be the thought that, in a sense, I was cutting myself off from the main stream of engineering development by spending so much of my life at sea. Maybe the shipping companies take care of this by arranging for their engineer officers to have several spells away from the sea, working with shipbuilders for example. Or does an engineer officer have to reach middle age before he goes into an office or works? It cannot be easy to make the adjustment from regulated operation and maintenance at sea to the life of an engineer on land, where the climate of initiative and co-operation in technical matters is quite different. I would want to know the answers to these questions before I took the plunge.

At least that is what I say now; at 21 or thereabouts I would probably have done what many others will no doubt do when they see this film, " Horizons Unbounded " —I would hope the superintendent engineer was going to accept me, so that I could combine work with pleasure in such a splendid life.

CAPRICORN

Weekly Survey

Water from the Sea

There has been a growing interest in the distillation of fresh water from the sea in the last few years. This has been partly due to the very big increase in demand for water for industrial applications which has already taken place since the war and which will go further in the next decade or two. On the supply side, it has been possible for a long time to de-salt salt water by a variety of chemical and physical processes. Last year the Pacific Gas and Electric Company of San Francisco established a generating plant at Morrow Bay to distil water at a cost of about 1·96 dol a thousand gallons. This compared favourably with the reported costs of 5·60 and 3·50 dol a thousand gallons at the Kuwait and Aruba installations in the Middle and Far East respectively. The Atomic Energy Commission in the United States has said that demineralisation plants powered by atomic energy could produce water in large quantities at between 25 and 39 cents a thousand gallons. The cost per gallon is indeed the critical factor now in turning salt water into fresh, and two methods have been the subject of major articles in ENGINEERING recently (25 April, p. 530; 16 May, p. 628).

G. and J. Weir, whose name was associated with the pioneering of evaporators in ships as long ago as 1880, have been concerned with the Middle East installations and they are now building a sea-water evaporating and distilling plant with a capacity of a million gallons in the Bahamas. Meanwhile in South Africa the Free State Geduld mine in the Orange Free State is having a plant installed which will turn brackish into fresh water by the electrodialysis process which has been developed with financial and technical aid from the Anglo-American Corporation of South Africa. The cost of treatment including redemption of capital and interest is calculated to be 2*s*. 6*d*. per thousand gallons and this compares very favourably with the operating costs of the San Francisco plant, though the salt content of the water is probably a good deal lower.

Recently it was announced that Marshall, Sons and Company of Gainsborough are to co-operate with the Cleaver Brooks Company, packaged boiler specialists of Milwaukee, in erecting a plant to distil water at Gibraltar. Technical resources and engineering experience have thus made significant strides in the last year or two to overcome the technical and economic problem of providing fresh water from the sea and from brackish sources at a price which comes within the budget of public utilities and private industry. Its implications for industrial communities rapidly expanding their water requirements and areas of limited rainfall wishing to raise crops are obvious.

Control Engineering

A recent Board of Trade survey has revealed that British industry as a whole is becoming fully alive to the growing importance of automatic techniques—which are now recognised as leading to reduced costs, increased output, and better and more constant quality. Citing the results of this inquiry, the President of the Society of Instrument Technology, Sir Harold Hartley, G.C.V.O., F.R.S., claims that control engineering has to-day reached the stage when it should be recognised as a " primary technology " (Sir Harold was delivering the Presidential Address to the Society at the annual general meeting in London last week).

Control engineering has developed its own philosophy and disciplines, and is finding an immensely wide field of application extending over guided missiles and satellites, aviation, continuous processing plants, the automatic control of mechanised production, and analogue and digital computers. Many recent impressive technological developments have only been made possible by control engineering. It is for these reasons that Sir Harold regards it as a primary technology—and considers that control engineering should " take its place in the engineering schools as an independent discipline."

How should a control engineer be trained? The mathematical theory of control—still incomplete in some essentials—demands a knowledge of statistical theory and probability, methods for dealing with non-linear differential equations, and numerical techniques applicable to digital computers. Mathematics, classical physics and electronics are the basic tools of the control engineer—but he must also have the range of knowledge and mental flexibility to weigh up whether mechanical, electrical, hydraulic or pneumatic control devices will best suit his immediate purpose, and how the system should be applied to optimise the performance of the plant.

Sir Harold suggests that the training of a control engineer should lie along the following lines:—during the first two years, a thorough grounding in fundamental physics and mathematics, which might well be common to all branches of engineering; in addition, the course should include some chemistry and some options. In the last two years would come the more specialised aspects, but there should be sufficient common ground between the various homes of engineering to ensure co-operation in the project times. " Finally, must come the years of training in industry, learning by experience how to apply principles in action, and how to solve the human problems that autocontrol will inevitably involve."

Defeating " Parkinson "

" Take care of the pence and the pounds will take care of themselves," our grandparents used to say—but they forgot to allow for the cost of counting the pence. In present-day business practices, too, overmuch emphasis may be placed on taking care of the pence: an organisation and methods study group sponsored by the Office Management Association has come to the conclusion that the amount of time and labour involved in checking and correcting mistakes—and in checking the checkers—can far outweigh the cost of allowing a few mistakes to remain undetected.

In their recently-published report, *The Control of Quality in the Office*, the group—which included representatives from the chemical and textile-fibre industries, steel tube manufacturers, the building industry and a large department store—propose that office management should come more into line with factory production thinking. Instead of aiming at absolute perfection in business records, reasonable tolerances should be set; and instead of 100 per cent checks, " batch sampling " could well be applied to certain types of office work.

The problem of raising the efficiency and establishing a satisfactory standard of quality control in the office, they suggest, should be attacked along two fronts: (1) analysing the errors with the object of raising the quality and reducing checking, but retaining the same basic methods of operation, and (2) modifying the working method to reduce the probability of error and the need to check. In the second category there are three possibilities: by eliminating or " automating " the transcription of data; by combining checks—e.g., checking the calculations on the copy, not on the original document; and by eliminating unnecessary precision. In costing and invoicing for example, they advocate

cutting out the pence—and possibly the shillings also—and working to the nearest pound. Apart from its wastefulness, they condemn multiple checking because "checking tends to detract from the individual's sense of responsibility for the quality of his or her own work—a sense that should be encouraged."

The report is published by the Office Management Association, 58 Victoria Street, London, S.W.1, at 9*s*.

Agreeable Noises from Canada

The British Dollar Exports Trade Mission has come to the end of their tour of Canada and their report will be available in due course. Reports from Canada indicate that the mission have been well received and are enthusiastic about the favourable atmosphere in the Dominion for British goods. The mission have been impressed, according to reports from British Columbia which is at the end of the itinerary, both by the desire to buy British goods and by the limited impact on Canada of the United States trade recession. It will be surprising if their report is not as enthusiastic as that put out by the Canadian Trade Mission to this country.

The optimistic view taken by the Canadian mission to this country and, to judge by current reports, by the United Kingdom mission now in Canada, is in marked contrast with the Gordon Commission on the Canadian economy published some time ago. That report favoured the development of Canadian industry, if need be, at the expense of United States trade but saw little prospect of Canada reducing its dependence on the United States in the foreseeable future. It was equally cautious about the prospect of a substantial swing in the volume of trade away from the United States to Western Europe including the United Kingdom. It has to be remembered too that some of the pro-British feeling at the moment is caused by the temporary upsurge of ill-feeling in Canada against the United States, which has been generated by political and economic events over the last year or two.

It will be time enough to identify the appearance of any long-term change of attitude in Canada, apart from the ones already mentioned, if the Conservative Party now in power there adopts an active pro-British trade policy or takes the initiative with constructive suggestions for further free trade between this country and Canada at the Ottawa Commonwealth Conference later this year.

Machinery on H.P.

The opening of a West End office by the United Dominions Trust Limited, which has hitherto operated its London business from its head office in the City, is a reminder of the wide activities to-day of hire purchase finance. Over half the hire purchase contracts in this country today are for motor vehicles and industrial equipment. Nevertheless hire purchase is operated over a wide range of engineering equipment from baking ovens and printing machinery to machine tools and contractors' equipment. The presence of U.D.T. at most exhibitions and agricultural fairs is a sign that to-day hire purchase is an important financial lubricant in the purchase of machinery.

Hire purchase finance is concerned with instalments where there is a marketable asset involved. In other words those who offer it are concerned that there should be a reasonable secondhand market in cases where equipment is to be sold off when payments are in default. It follows from this that financing of assets which do not have a ready secondhand market is not as yet considered a very profitable field for the hire purchase companies.

Given time and enterprise it might be possible for the very considerable resources of the hire purchase finance houses to be deployed in part to finance laboratory equipment and even research programmes. This would clearly have to be approached with circumspection by both sides to an agreement but there seems no reason why it should not be considered a fruitful develpment in banking—and the well established hire purchase companies are anxious to establish their reputation as bankers as well as hire purchase financiers.

Small Cars in the U.S.

Latest reports from the United States suggest that American automobile manufacturers are having cold feet about entering the small car market. Both the General Motors Corporation and Ford Motors are thought to have designs and production programmes ready but are delaying a decision because the potential market is too small. The Chrysler Corporation is thought to be somewhat further behind in its preparations while Studebaker-Packard's small car, like the American Motors' Rambler, is not a small car in the true sense of the word.

It is thought that the United States market for car imports is running at about 300,000 to 350,000 units a year at present compared with a long-term annual average of 275,000. These figures are thought to be too small to make it worthwhile for one of the big automobile companies to tool up for production. If one or more of them went into this market it is thought that they would be in serious trouble with no prospect of getting back their investment.

It is possible that some of these reports are a smoke-screen to frighten off potential competitors. It is certainly too soon to say that the threat to the British small car market in the United States has now come to an end. On the other hand it is possible that cyclical trends may reinforce the United States automobile companies' attitude not to have anything to do with small cars except as importers. The American recession is flattening out and when definite recovery sets in, there may be a swing in public taste away from the small car back to the larger American models. This swing might be of the order of 5 to 10 per cent and would not seriously damage the long-term prospects of European companies exporting small mass-produced cars into the United States.

Research and Development

The announcement in the House of Commons last week that the Government is to set up a committee to investigate the management of research and development by State departments comes at the right time. The decision, announced recently in the White Paper on the future of the aircraft industry, that the research activities of Government departments hitherto concerned with military aircraft are to be switched to civil work has aroused certain misgivings. It takes away some of the proper functions of companies in the industry and puts a powerful instrument of control for the future in the hands of the Government. There has also been a good deal of criticism, some of it in public, of the functions which the Lord President of the Council has to carry out in granting public money and administering its use through scientific advisory committees.

The terms of reference of the committee which are being set by the Lord President of the Council are: "to inquire into the techniques employed by Government departments, and other bodies wholly financed by the Exchequer, for the management and control of research and development carried out by them or on their behalf, and to make recommendations." The membership of the committee is given on page 680 of this issue, and it will be seen that a balance has been maintained between industrial experience, technical and academic interest and the Civil Service.

Letters to the Editor

QUALIFICATIONS FOR MANAGEMENT

SIR, Capricorn's description (16 May, p. 610) of the small precision engineering firm which is successfully run by a managerial team without a professional qualification between them, is surely of great topical interest in connection with the attention that has been focused recently on the question of technical training for industry. In our current anxiety to provide higher technical education for more and more people, are we not in great danger of overlooking the vital basic question of what form this education should take?

Examination syllabuses expand every year, placing an increasing burden on students' memories so that they may be equipped with an enormous quantity of purely factual knowledge, a large proportion of which will certainly not be of any use to them later on. This process inevitably means that less and less time is spent in a rigorous examination of first principles and the development of independent, constructive and imaginative thought, which is surely far more important than memorising any number of facts.

The example quoted by Capricorn is, of course, an exceptional case, but it does serve to highlight the question of whether our present educational policy is, in fact, producing the required results. Would it not be eminently worthwhile to examine the underlying reasons why so many successful examination candidates subsequently fail to make any great contribution in industry (or, indeed, in many other fields), while a small but significant fraction of those who have had virtually no formal education nevertheless seem to be able to develop independently lucid thinking habits and a truly constructive attitude to their problems?

Yours faithfully,
M. SHALIT.

14A Hillmorton Road,
Rugby.
22 May, 1958.

ENGINEERS' SALARIES

SIR, I am afraid that I must ask for the courtesy of your space in order to comment on the letter over the signature of Mr. J. G. Orr, secretary, the Engineers' Guild (ENGRG., 23 May, p. 643).

The ethics involved in an officer of one organisation obtaining a circular issued to honorary officers of another organisation and then going out into the public Press to comment on this document are, I should have thought, questionable. If this is to become a general practice the results are likely to be harmful to public life.

The Institution reached its own decision as to the kind of evidence which it should give to the Royal Commission on Doctors' and Dentists' Remuneration and is responsible only to its own membership for it. It is the fact that the line taken by the Institution has at no stage been questioned by any of the engineering branches of the Institution, nor was it questioned in any way at the Institution's annual conference which has just concluded.

There can be no question that salary scales and promotion ladders are both parts of a complete story of professional remuneration. The difficulty in the Civil Service is that remuneration of civil servants has, by the definitions prescribed by the Tomlin Commission of 1931 and the Priestley Commission of 1955, always been derived from what is known of salaries outside the Civil Service. There is an inclination sometimes to imagine that the Government is a model employer. This is not the case. The Treasury, in the evidence it gave to both the Commissions referred to, made it very clear that it was no part of their concept of Civil Service remuneration that the Government should be a model employer. The Treasury proposed to do no more than to follow the general trend of what it believed that "good employers" do. Furthermore, in the

Continuing Letters to the Editor

Civil Service, there is a grading scheme of a tightness quite unknown in industry. These things produce a situation in the Civil Service in which professional officers in the building and engineering fields feel themselves to be very much a depressed area, both in terms of remuneration at particular grade levels and in career prospects. This is a situation which almost inevitably follows from Civil Service salary scales being derived from inadequately known general considerations.

There is, in the Civil Service, a new organisation set up between the staff and official sides of the Civil Service National Whitley Council known as the Civil Service Pay Research Unit. That organisation is to undertake a survey of the remuneration of professional officers in the Civil Service where the types of work and responsibilities will be the subject of a detailed survey within the Civil Service and a detailed comparison outside the Civil Service. Until this exercise is undertaken and completed, and this will not be until the early months of next year, it is wholly inappropriate for Civil Service conditions to be regarded as a guide to anyone as to what is proper in either grading structures or remuneration.

Mr. Orr takes exception to the criticism that I made in my private circular to Institution honorary officers of the rashness of the Guild with its small membership and, therefore, its lack of experience and knowledge, entering into this field and making comments and observations about engineering remuneration on inadequate bases. One quite understands Mr. Orr's dislike of such criticism but where does that get either him or the Institution or, more importantly, engineers in the Civil Service?

The important thing for engineers in the Civil Service, as also for architects, surveyors and so on, who share similar conditions, is the inquiry about to be undertaken by the Civil Service Pay Research Unit which will be taking responsibilities and organisation in their general relationship to pay into consideration.

Yours faithfully,
STANLEY MAYNE,
General Secretary.

The Institution of Professional Civil Servants,
28 Broadway, London, S.W.1.
22 May, 1958.

DIESEL CRANKCASE EXPLOSIONS

From Air Commodore Sir Vernon Brown

SIR, On page 591 of your issue of 9 May reference was made to certain Questions which were asked in the House of Commons on 29 April about the researches which had been carried out by the British Shipbuilding Research Association and the Imperial College of Science and Technology into the causes and prevention of explosions in the crankcases of marine diesel engines.

In his reply, the Parliamentary Secretary to the Ministry of Works stated that following extensive trials at sea, a photo-electric automatic device had been developed which would give warning of dangerous conditions sufficiently early for remedial action to be taken, and that this apparatus was now being manufactured commercially.

It may be of interest that the oil mist detector referred to was developed, and is now being manufactured, by this company, and that its use in British passenger ships has now been formally approved by the Ministry of Transport and Civil Aviation. Furthermore, it is understood that if an oil mist detection system is installed on the engines of passenger ships the Ministry will approve a reduction of 50 per cent in the area of relief valves, i.e., from $\frac{1}{2}$ sq. in to $\frac{1}{4}$ sq. in per cu. ft of gross crankcase volume.

I am, Sir,
Yours faithfully,
VERNON BROWN,
Director.

Graviner Manufacturing Company Limited,
29 St. James's Street,
London, S.W.1.
13 May, 1958.

Editor's Note: The Graviner-BSRA oil mist detector was the subject of an article "Developments in Crankcase Oil-Mist Detector" in the 6 September, 1957, issue of ENGINEERING, page 303.

Obituary

DR. CHARLES PENROSE

It was with great regret that we learned of the death on 17 May, at his home in West Chester, Pennsylvania, of Dr. Charles Penrose, chairman of the Newcomen Society in North America. He was 72 years of age and had been in poor health for some months, following a severe heart attack in December last, but he had continued to take a keen personal interest in the affairs of "American Newcomen"—for the impressive growth of which he was primarily responsible—and the news of his death was quite unexpected by his many friends in this country.

Charles Penrose was born in Philadelphia on 24 January, 1886. Proud as he was to be a Pennsylvanian, it was a source of no less satisfaction to him that he could trace his ancestry back to the village of Penrose, in Cornwall, in the Eighteenth Century. He was educated in Dresden, Germany, and in the Episcopal Academy at Philadelphia, whence he proceeded to Princeton University. He obtained the degree of Bachelor of Science in 1907, but continued his studies for a further three years, to qualify in electrical engineering, and then joined the Philadelphia Electric Company as assistant to the chief electrical engineer. In 1914-15 he was in charge of the erection of the company's Schuylkill No. 2 station, and was subsequently engaged on other extensions to their plant. In 1917, however, he left them to begin an association of nearly 40 years with the firm of Day and Zimmerman, Inc., consulting engineers, of Philadelphia. He was their assistant general manager until 1932, when he was appointed a vice-president, and retained the latter office until about four years ago. During the first World War, he was progress engineer on the construction of the United States Army Supply Base at Philadelphia, and between the wars served as consultant to the United States Government in connection with the Federal Housing Administration.

Penrose's connection with "American Newcomen" began more than 30 years ago, when that society, now a separate entity with some 15,000 members, consisted only of the few American members of the parent Newcomen Society for the Study of the History of Engineering and Technology, founded in London in 1921. One of them, L. F. Loree, president of the Delaware and Hudson Railroad, had invited the late Dr. H. W. Dickinson, of the Science Museum, to address a gathering of railroad presidents in New York on the occasion of the Delaware and Hudson's centenary in 1923. This meeting led to a luncheon given by Loree in the Bankers' Club, New York, where Dickinson was asked to expound more fully the historical purposes of the Newcomen Society. As a result, an American branch was formed, but with the additional objective that it might become an informal link between American business leadership and the United Kingdom. This conception so fired Penrose—the youngest man present—that when, in the course of time, he found himself in a position to do so, he made it the great purpose of his life. The historical aim was not abandoned, but it was made rather the means by which his main purpose was to be achieved. In this he was notably successful, bringing together at intervals, in each of the 80 or more Newcomen centres in North America, the leaders of the professions and of commercial and industrial enterprises, who otherwise would have had, in most cases, no common meeting ground, and steadily striving towards his ideal of a closer mutual understanding between them and their British "opposite numbers," many of whom he enlisted in his ranks. The value of his idealism to the Allied cause during the second World War never received public recognition, but it was immense, and brought him the personal friendship of a succession of British Ambassadors and Ministers in Washington; notably that of the late Lord Lothian, whose memory was recalled at every dinner of American Newcomen.

Though his interests and activities were so widespread—for many years, until he was nearly 70, he travelled never less than 60,000 miles annually—Dr. Penrose retained a close contact with engineering, and in various branches. He was a member of the American Society of Mechanical Engineers and of the American Institute of Electrical Engineers, and an Associate Member of the American Society of Civil Engineers. He was also a member of the Board of Managers of the Franklin Institute, a Fellow of the Royal Society of Arts, and a Vice-President of the (British) Newcomen Society, and had served on various American associations of the electrical industry and the cotton industry. He was an LL.D. of Cumberland University, Tennessee, a D.Eng. of the South Dakota School of Mines and Technology, and held honorary degrees of at least four other Universities in the United States. As a writer, he did much to collect and record details of the careers of the pioneers of American engineering, technology and industry, mainly by contributions to the Newcomen Society of North America; but the Society itself represents the great work of his life, and it is by that, and his innate capacity for friendship, that he will be chiefly remembered.

FORTY HOURS ARE ENOUGH

Dr. Erhard has made no secret of the fact that he regards cuts in the working week as unrealistic in the present phase of the development of the German economy. Dr. Etzel, the Finance Minister, made the same point in presenting the budget earlier this year when he said that raising defence costs meant that any rise in the standard of living must come out of increased productivity. Nevertheless, union pressure for a shorter working week has been kept up. Under agreements recently signed by representatives of management and labour, some 3 million workers in the steel, metal, machine making and garment industries will have a 44 instead of a 45 hour week, starting in October. For many of the workers involved this cut will simply mean an extra hour of overtime pay. The move for shorter hours has been going on since 1955 when the D.G.B., the Federation of German Trade Unions, came up with an Action Programme demanding a 5-day week. Their slogan "40 *Stunden Sind Genug*" appeared in posters and press advertisements throughout Western Germany.

This attitude brings little comfort to the employers, however, as contracts stipulate that workers' weekly income must not suffer from cuts in working time. And those employers not in a position to cut hours by installing new machines and rearranging production lines find themselves forced into paying more overtime or taking on extra men to keep up production. Although well over half Germany's industrial workers now have a 45-hour week, the prospect of getting down to the target of a 40-hour week fills the German public with alarm and despondency. A poll carried out by an independent research institute recently showed a big majority against increased wages or shorter hours for industry if these meant higher prices. It is quite on the cards that a poll on these lines in Britain just now would produce the same result.

Plant and Equipment

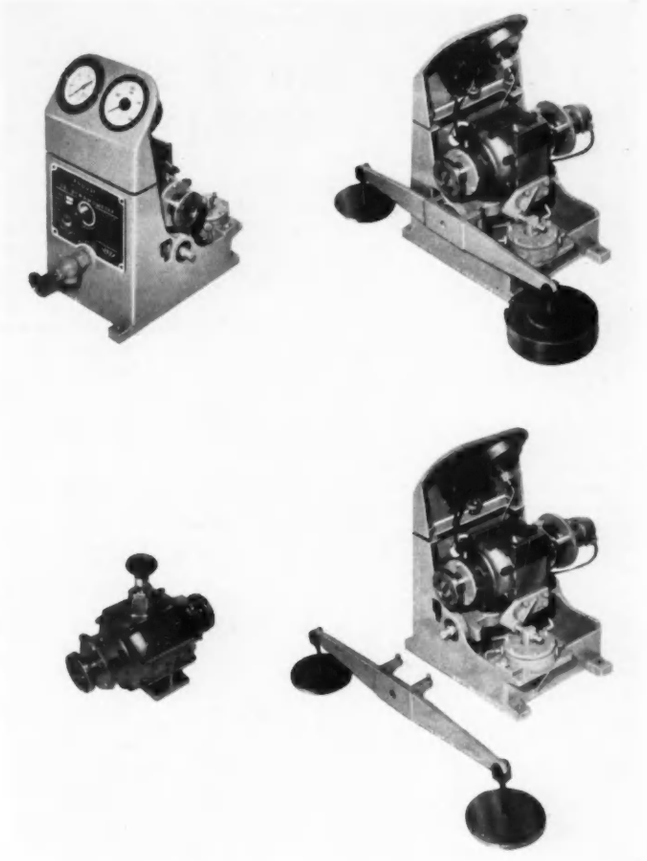
SIMPLE DYNAMOMETER

For the many applications when it is required to apply a regulated load to an engine or motor but where extreme accuracy is not needed, the standard hydraulic dynamometer is an unnecessary expense. To replace it, Heenan and Froude Limited, Worcester, have developed the E.I. brake, which is shown in the accompanying illustration. When only a simple power absorbing unit is wanted the E.I. bolts directly on to the bed plate, but when it is required to measure the torque it is mounted on a pivoted platform and fitted with a lever arm in the manner shown.

The brake unit elements are of the standard Froude pattern but are only single sided. The resulting axial thrust is taken by the bearings. The load at any speed depends on the amount of water discharged into the brake casing by the impellor on the brake shaft. This quantity is controlled by hand valve fitted on the casing. A simplified, cheaper machine results. The pivoting is also different. The bearings are placed below the shaft axis and a short lever arm bears on a pressure capsule. The latter is connected to a pressure gauge calibrated to read torque, and this, in conjunction with a tachometer, enables the power absorbed to be calculated. At full torque the error is less than 1 per cent. Although normally fixed to the panel as shown, the torque meter can be mounted remotely, 20 ft of small-bore piping being supplied for this purpose.

Provision is also made for checking the torque meter accuracy. A quick-fixing lever arm with balance pans and dead weights slips over the pivot bearings and loads the pressure capsule. The meter reading should then follow the addition of weights to the pan. Owing to the pivoting movement the dynamometer must be driven through a cardan shaft with universal joints.

Three sizes are at present being made; they span the range from 25 h.p. at 4,600/6,000 r.p.m. to 100 h.p. at 2,500/4,000 r.p.m.



Where torque measurements are only needed to within 1 per cent, the E.I. dynamometer unit can be used.

REMOTE LEVEL CONTROLLER

A new capacitance-type industrial level controller, the Proxicon Mark III, has been introduced by J. Edward Hall (Electrical Engineers) Limited, Clarence Road Works, Leeds, 10. It is designed to control the levels of any liquids or free-flowing solids without necessitating direct contact with the material, with no moving parts in the container. The principal advantage claimed for the new instrument is the addition of tapped electrode terminals, whereby remote control can be extended up to 3,000 ft using standard types of cable.

Other advantages over Hall's earlier Proxicon controllers include the incorporation of a heavy duty contactor type double-pole change-over relay with Elkonite faced contacts, in place of the Post Office type, which gives greatly improved contact life and increased flexibility in control circuit functions. The provision of a trigger circuit ensures snap operation even with a slow capacitance change, due to slow movement of material levels.

The addition of a separate signal station unit, which incorporates the mains voltage signal lamps formerly included in the main control unit, has eliminated overheating and allows unrestricted siting for easy visibility. Improved circuitry and manufacturing techniques set a new standard in enabling sensitivities greater than 1·0 pf to be achieved under all conditions subject to variations of not more than ±0·25 pf with mains variations of +5 per cent to −7½ per cent and not more than ± 1 pf with temperature variation of ±20° F from a 68° F datum figure.

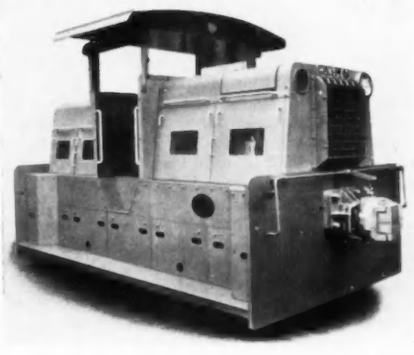
Valves and " plant-alive " indicator lamps are resiliently mounted; ease of inspection and servicing has been particularly studied. An electrode switch is provided for selection of high or low level operations, with a " fail safe " feature in either condition of working. The set point is situated in a very accessible position, and can be easily adjusted on site.

The instrument can be supplied for single and dual level applications, voltage ranges 100/125, 200/250 and 360/450 volts, cycle range 40/60. Three voltage tappings are incorporated for each range to enable exact site voltage to be selected.

SHUNTING LOCOMOTIVE

The " Yardmaster " is a recent addition to the range of industrial shunting locomotives made by the Hunslet Engine Company, Limited, 125 Jack Lane, Leeds, 10. It is designed for simplicity in operation and maintenance. The controls are so arranged that the driver can reach them from either platform as well as from his normal seated position, an arrangement that speeds up one-man shunting in the yard. The cab can be open, as in the illustration which is of a locomotive for Southern Rhodesia, or enclosed and fitted with heaters for use in cooler climates. Alternative engines are the Gardner 4LW or the Dorman 4LB, developing 71 b.h.p. at 1,700 r.p.m. Transmission is through Layrub couplings to the Hunslet torque converter and two-speed constant-mesh gearbox.

Gear changing is carried out by a selector lever which operates a hydraulically controlled clutch giving a very light action and eliminating the need for the operator to synchronise the shaft speeds. In first gear the maximum tractive effort is 8,800 lb falling to 2,000 at the top speed of 10 m.p.h. The locomotive will traverse curves down to 60 ft radius with ease, and will run on rails as light as 35 lb per yard. The weight in working order is 13 tons.



Continuing **Plant and Equipment**

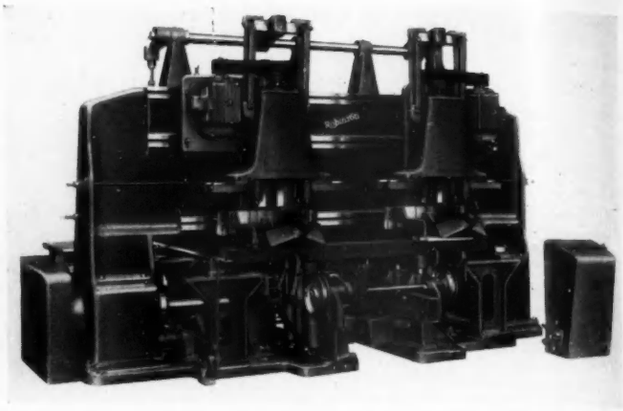
TO MAKE RAILWAY SLEEPERS AUTOMATICALLY

Railway sleepers can be trimmed to length, marked, adzed for chair seating and bored automatically at a rate of up to 10 per minute on a machine designed and built by Thomas Robinson and Son Limited, Rochdale. The machine is controlled by one man from a central panel. Sleepers of any length from 6 ft to 9 ft, and for any track gauge from 1 metre to 5 ft 6 in can be handled, in nominal widths of 8, 10 or 12 in, and in nominal depths of 5 to 6 in.

Lengths of timber are placed on the infeed chain conveyor, which carries them into the machine. An optional feature, which can be incorporated in the machine in a position between the feed point and the adzing spindles, is a cross-cut circular saw. This is adjustable to suit sleepers of different lengths, and can cut up to 2 ft from over-length timbers. The cut ends are led by an angled fence to a large storage space within the machine outline. A 10 h.p. motor drives the saw, which is 24 in diameter, and is easily accessible through a hinged portion of the machine table.

There are two independent, horizontally adjustable adzing spindles, each ball bearing mounted and driven by V-belts from a 10 h.p. motor. Each spindle carries a solid two-knife cutter block, with a normal cutting circle of 11 in, suitable for working chair seatings up to a maximum of 22 in long. The cutters can be set for either horizontal or 1 in 20 angular seatings, and shoulder cutters are fitted to leave a clean edge to the cut seatings.

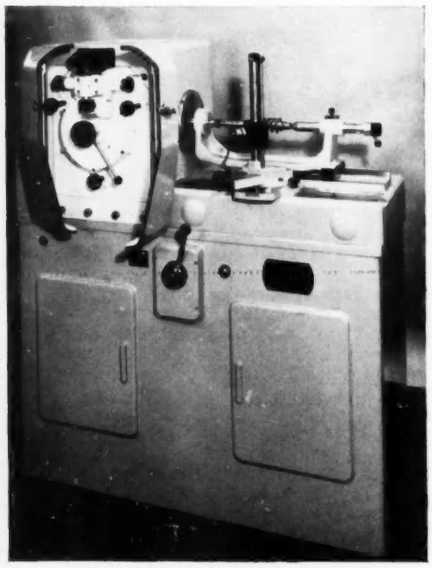
Next in line to the adzing heads comes a pair of independently adjustable boring heads, which can be set to bore any number of holes up to four at each end of the sleeper, either vertically or at the 1 in 20 angle, like the seatings. The boring spindles are adjustable between centres of 2½ in and 6½ in in the width of the sleeper, and 4 in and 17½ in in the length. A 10 h.p. motor drives each set of spindles through a gearbox. All the spindles are for right-hand augers, thus saving in first cost and simplifying maintenance. Spindle downfeed is by the weight of the boring unit slide, with some spring assistance when starting to bore; undue resistance caused by a broken auger would stop the downwards motion of the boring heads, and thus confine the damage to the broken auger. Withdrawal of the heads is positive.



Railway sleepers are trimmed, prepared for chairs and bored, at a rate of up to 10 per minute on the Robinson automatic machine.

The machine adjusts itself automatically to accommodate uneven or taper-sawn sleepers. All the driving motors, which are of the totally-enclosed, fan-cooled, high-torque type, are identical and interchangeable. Full guarding and exhausting equipment is provided, and the machine can be adapted without difficulty to fit into a conveyor system. Normally only one feed rate is provided; up to 10 sleepers per minute for soft woods, and up to 6 per minute for hard woods. Where the machine will be required to deal with both types of timber, change pulleys can be supplied for altering the rate as necessary.

LEAD MEASURING MACHINE



One of the exhibits on the stand of J. Goulder and Sons Limited, Kirkheaton, Huddersfield, at the recent Gauge and Tool Exhibition was their lead measuring machine for checking the helix angle of gear wheels, threads and the like. Leads from zero to infinity can be measured on gears up to 14 in diameter and 5 in long (in the gap), or 8 in diameter and 7 in long between centres. The lead can be checked over 3 in axial movement.

The gear to be checked is mounted on a quill shaft which runs in the head of the machine. The drive to this quill is through a friction wheel bearing on it, which can be inclined at any angle to give a combination of rotary and axial movement of the quill. Once the angle has been set the doors are closed to prevent any alterations being made during the measuring cycle. Operation of the starting handle releases the locking pins and then starts the driving motor; the quill then automatically moves outwards, pauses and returns, the locking pins re-engaging at the end of the stroke.

During the movement of the gear the stylus bears against one flank and any variation from the set path is recorded on a Taylor-Hobson recorder. Magnifications from 100 to 5,000 times are obtainable.

ABRASIVE BELT MACHINE

A new addition to the range of abrasive belt machines made by Taylor Tools and Supplies Limited, Broadheath, Altrincham, Cheshire, is shown in the accompanying illustration.

A 1 h.p. totally enclosed motor housed in the base drives the abrasive belt at 4,000 ft per min,

and belts from ¼ in to 2 in wide can be fitted. The smallest contact wheel is 1 in, and the largest 3 in diameter; these wheels can be changed in a few seconds, as can the belt.

Additional idlers can be fitted on the radius arm to alter the angular disposition of the belt, and the arm itself can be set at various angles. The machine can equally well be used on a bench.

SEALING TUBELESS TYRES

Punctures in large tubeless tyres, particularly of the size used on earth-moving vehicles, invariably result in the air-seal being lost, and manual handling of the tyre without equipment is often unsuccessful. The Pull-Jack, now being introduced by the Rotolift Sales Company Limited, Glasshouse Street, St. Peters, Newcastle upon Tyne, has been designed to overcome this problem. The hardened steel link flexible chain is placed around the circumference of the tyre when it is ready for re-inflation, and the action of the tool compresses the tyre, forcing the beads against the rim flange thereby creating an air-seal while the tyre is in the initial and critical stages of inflation. The action is easily carried out and shows a considerable saving in time and manual effort. The Pull-Jack is available for use on tubeless tyres from sizes 1400 by 20 up to 2700 by 33 and is fitted with 30 ft of chain.

The Pull-Jack is a completely general-purpose tool and a large variety of uses can be found for it. All the mechanism is totally enclosed and the brake acts instantly. It can be supplied in three sizes with capacities of ¾, 1½ or 3 tons; the ¾-ton model weighs only 19 lb and when stowed away measures only 20 in by 4½ in by 5½ in.

NEW RANGE OF MOBILE CRANES

Fifteen models make up the new range of Coles mobile cranes introduced by Steels Engineering Products Limited, Sunderland. They are of three types, self-propelled, shunting locomotive and truck-mounted, and the capacities covered are from 6 to 45 tons. All the cranes are diesel-electric, with very simple controls giving infinitely variable speeds on all motions, and all share certain other basic features, including double row ball bearing slewing rings and pilot switch controls operating heavy contactors.

The smallest crane in the series, model S510, is a self-propelled machine mounted on four wheels, with a cantilever jib normally 20 ft long, and a lifting capacity, at 7 ft radius, of 6 tons. A 30 ft jib is also available, as are jib extensions.

Smallest in the new range of Coles cranes, this model will lift 6 tons at 7 ft radius.

A Ford diesel engine of 52 b.h.p. provides the power for a variable voltage generator; and there are four electric motors, one of 10 h.p. for hoisting, one of the same power for derricking, one of 2 h.p. for slewing, and one of 10 h.p. for travelling. Control is by pilot switches mounted on the panel in front of the operator, and the normal routine is to engage the switches for the motion or motions required while the engine is running at a reduced speed, and then control the speed of the motion as required by means of the accelerator. To stop the motion the spring-loaded switch is allowed to return to the off position; an electro-mechanical brake then acts automatically. Totally-enclosed self-resetting limit switches are fitted to prevent overwinding or overloading on the hoist motion, and overderricking beyond prescribed limits.

Operating speeds are 80 ft per min hoisting with a light line or 50 ft per min with a load of 2 tons; 20 sec from maximum to minimum radius derricking; 2 r.p.m. slewing; and 3 m.p.h. unladen or 2 m.p.h. laden travelling. An indicator on the jib shows safe loads at all radii.

Similar cranes in the self-propelled range will lift 10 tons at 9 ft radius, 17½ tons at 10 ft, 25 tons at 10 ft and 45 tons at 12 ft respectively.

LOCOMOTIVE CRANES

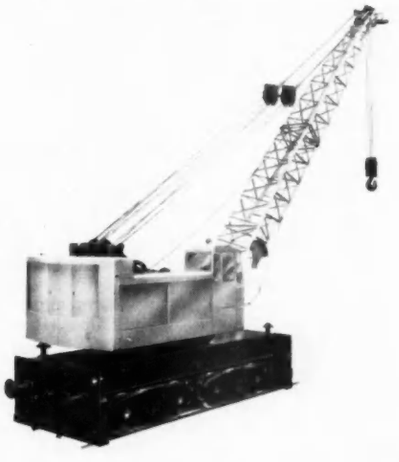
A typical crane from the locomotive range, the R1110, is similar in superstructure details to the smallest of the mobile cranes, having a Ford diesel engine of 52 h.p. and four motors, those for the joisting, derricking and slewing motions being of 11 h.p. each, while the travel motor is of 15 h.p. This crane has as standard a cantilever jib 20 ft long; a 30 ft jib and extensions are available as extras if required. Like all the other cranes in the complete range, it has full-circle slewing in either direction. Mounted on four 31 in diameter wheels the crane is suitable in its standard form for rails at 4 ft 8½ in gauge, but the undercarriage can be arranged for other gauges from metre to 5 ft 6 in as required. Lifting 10 tons at 9 ft radius, the crane has a travelling speed of 400 ft per min on level track. A similar model, but with a strut jib, lifts 12½ tons at 10 ft radius, and another machine in the range lifts 17½ tons at 10 ft radius; this crane is carried on twin four-wheeled bogies. A similar double-bogie locomotive crane has a lifting capacity of 25 tons at 10 ft radius.

Largest of all the rail-mounted cranes in the range is the R5010 locomotive crane which, powered by a 100 h.p. diesel engine, will lift 45 tons at 12 ft radius on its 50 ft strut jib.

TRAVELLING ON THE ROAD

To meet the requirements of crane owners who use their machines at different sites separated by public highways, the new Coles range includes truck-mounted models which can be driven as ordinary road vehicles when necessary. Typical of this group of cranes is the model L1110. It has a superstructure similar to the other cranes in the complete range, and is powered by a Ford diesel engine developing 47 h.p. Hoisting, derricking and slewing motors are each of 10 h.p., and the crane, which has a 20 ft cantilever jib as standard equipment, will lift 10 tons at 9 ft radius. The chassis is specially designed for crane carrying, and is mounted on six wheels, the rear two pairs being twin. An A.E.C. six cylinder diesel engine developing 103 h.p. provides the motive power, driving the twin rear axles through a five-speed gearbox. An auxiliary gearbox gives extra low road speeds for bad conditions. In top gear the crane has a maximum road speed of 29·7 m.p.h. It is fitted with normal type brakes on the road wheels, and has full electric lighting equipment. A similar model has a lifting capacity of 12½ tons at 10 ft radius, and the next larger in the range lifts 17½ tons at 10 ft. A crane to lift 25 tons at 10 ft radius is also available in this range, which is completed by a machine of 45 tons capacity.

This large crane, which lifts 45 tons at 12 ft radius, is powered by a Perkins diesel engine of 96 h.p., and has a hoisting motor of 82 h.p. The derricking and slewing motors are each of 57 h.p. A 50 ft strut jib is standard, and this jib is made in two sections, the top 25 ft being removable for travelling on the road. Jib



At the other end of the scale is a rail-mounted crane capable of lifting 45 tons at 12 ft radius.

The 45 ton crane is also available as a self-propelled pneumatic tyred model as illustrated, or mounted on a truck chassis to travel on public roads.

extensions can be supplied, and a gantry mast is also available to enable the crane to erect and change its own jibs. A Rolls-Royce six cylinder diesel engine of 250 h.p., driving through a fluid coupling and an eight-speed gearbox, gives the vehicle a maximum road speed of 27 m.p.h. in top gear. Normal road brakes and lighting equipment are fitted.

VERSATILITY

To make Coles cranes suitable for operating conditions in all parts of the world, and to meet the needs of individual users, many extra fittings are available. Common to all the cranes in the range are special cabs, with heaters and Fibreglass insulation for arctic conditions, or with fully opening windows and a ventilating fan for use in hot countries.

A safe-load indicating device can also be fitted to any of the cranes. This consists of a weighing mechanism, mounted inside the jib on cranes of the cantilever jib type, or in the derrick rope system if the crane has a strut jib. Continuous measurement of the load is made by means of the rope tension, and visual and audible warnings are given if the load or the derricking of the jib approach dangerous conditions. If the warnings should be ignored, the hoisting and derricking motions are cut out automatically. A light panel in the operator's cab gives the visual warning. As long as the safety limit is not reached, a green light shows. When the load or the derrick angle approach danger a yellow light comes on. If no suitable action is taken, a red light is illuminated and a bell sounds. Failure to take corrective action causes the hoisting and derricking out motions to cut out. All the operator can do then is to lower the load to the ground or derrick in to the correct radius for the load. The safety device then re-sets itself, and normal working can continue.

On mobile and truck-mounted cranes four or six wheel drive can be fitted, as can power-assisted steering on the larger machines. A second cab, for the driver's mate, can be fitted on truck-mounted cranes, and on some of these machines it is possible to have dual control, which enables the operator to drive and steer the chassis from the crane cab, when short movements about a site are needed. Jib extensions, grabs, dragline gear, magnets, and a variety of minor items of equipment combine to make the range of cranes extremely versatile.

In Parliament

GOVERNMENT EMPLOYMENT OF RESEARCH RESOURCES

Attention was drawn by Mr. Bernard Braine (Conservative) in the House of Commons last week to the need for making the best use of scarce sources of scientific manpower and he urged that an investigation should be made into the employment of research scientists by the Government.

Replying, in his capacity of representative in the Commons of the Lord President of the Council, Mr. Harmar Nicholls, the Parliamentary Secretary to the Ministry of Works, stated that Viscount Hailsham had decided to set up a committee for that purpose. Its terms of reference would be: "To inquire into the techniques employed by Government departments, and other bodies wholly financed by the Exchequer, for the management and control of research and development carried out by them or on their behalf and to make recommendations."

The chairman of the committee would be Sir Claude Gibb, K.B.E., chairman and managing director of C. A. Parsons and Company Limited. The other members would be Dr. Willis Jackson, F.R.S., director of research and education, Metropolitan-Vickers Electrical Company Limited; Dr. R. P. Linstead, C.B.E., F.R.S., Rector, Imperial College of Science and Technology; Mr. A. A. Part, M.B.E., Under-Secretary, Ministry of Education; and Sir Solly Zuckerman, C.B., F.R.S., Professor of Anatomy at the University of Birmingham. Mr. D. Neville Jones, of the office of the Lord President of the Council, would be the secretary to the committee.

[Comment on the setting up of this committee will be found in a Weekly Survey note on p. 675.]

REJECTION OF JOINT COUNCILS FOR ENGINEERING AND SHIPBUILDING

A statement from the Minister of Labour and National Service in respect to action being taken by employers and trade unions in the engineering and shipbuilding industries to establish National Joint Industrial Councils in their industries was asked for by Mr. John Leavey (Conservative). He pointed out that the setting up of such Joint Councils was recommended by the Courts of Inquiry into conditions in those industries, when making their reports in April last year.

He was informed by Mr. Iain Macleod that, soon after the publication of those reports, he had asked the organisations concerned whether they had reached any conclusions on the desirability of setting up Joint Councils. In respect to the engineering industry, the Engineering and Allied Employers' National Federation had replied that, after very careful consideration, they had reached the conclusion that the suggested National Joint Council for the engineering industry would not achieve the result desired by the Court of Inquiry.

They were of the opinion that the existing procedure for the avoidance of disputes worked satisfactorily. The Confederation of Shipbuilding and Engineering Unions repeated the statement made at the Court of Inquiry that they considered that the setting up of such a body, with wide terms of reference, would be advantageous to the industry.

In respect to the shipbuilding industry, Mr. Macleod stated that the Shipbuilding Employers' Federation had said that, in the present circumstances, they did not wish to pursue with the Confederation of Shipbuilding and Engineering Unions the question of setting up a National Joint Council for the industry. The Confederation said that they could not agree to the proposals in the report and that the existing arrangements should continue to operate. He regretted that the suggestion made originally in 1954 by the Court of Inquiry for the engineering industry and reinforced in 1957 by the Courts of Inquiry for both industries, had been rejected. It was, however, for the organisations themselves to agree upon machinery for the discussion of wages and other conditions of employment, as well as other matters of joint interest affecting the productive efficiency of these industries.

LACK OF SHIPPING FREIGHTS

The attention of the Minister of Transport and Civil Aviation was drawn by Mr. John McKay (Labour) to the decrease in the demands for British cargo shipping. He asked if the Minister was aware that influential people in his constituency, Wallsend-on-Tyne, had been suggesting that imports by the National Coal Board should be restricted to British ships. Mr. McKay said he felt that such a restriction would be a bad principle to adopt, not only for the Board but also from the point of view of the nation's shipping interests generally.

Mr. Harold Watkinson replied that the decline during the past year in dry cargo freight rates had affected shipping throughout the world. It was not the policy of the Government to interfere in the commercial operation of shipping, but the position was being watched very closely. The principle on which British shipping had founded its prosperity in the past was that this country had gained more out of the freedom of trade and the freedom of the seas than any other nation.

DRY DOCKS ON TYNESIDE

The Chancellor of the Exchequer was urged by Captain E. W. Short, Labour Member for Newcastle upon Tyne Central, to make a substantial financial contribution to the two proposed dry-dock projects on Tyneside. He asked the Chancellor to bear in mind that the Tyne was the major ship-repairing centre in this country and that there was a certain amount of unemployment at present. If the shipping slump continued, that unemployment would spread and the two dry-dock projects were therefore extremely important. Finally, in view of the Chancellor's Budget speech, he wondered whether there was a possibility of some new arrangement or whether assistance was envisaged under the existing Distribution of Industry Act.

Mr. Heathcoat Amory said that he was prepared to consider applications in respect of these projects and they would be considered on their merits. The amount of any contribution must depend on the circumstances. If, as in this case, the claim for assistance arose in a special area, it would be granted under the existing Distribution of Industry Act. If a claim applied to a place outside one of those areas, it would fall to be considered under the new Bill, now before the House.

UNIVERSITY COURSES IN RUSSIAN

It was claimed by Mr. Barnett Janner (Labour) that only about 2 per cent of all science graduates in Britain had even a slight knowledge of Russian and he appealed to the Chancellor of the Exchequer to increase the facilities for the teaching of that language, so as to provide an adequate preparation for life for scientists in modern circumstances.

Mr. Janner stressed the position that very few secondary schools possessed facilities for teaching Russian and that one periodical had described the present position by stating that the number of such schools which offered instruction in that subject was ridiculously small. That position surely meant that scientists of standing had to spend a considerable amount of time in learning Russian in order to be able to cope with various Russian publications. Encouragement should be given in the form of grants and by other means to further the teaching of this language.

It was true, Mr. Heathcoat Amory replied, that relatively few science graduates had a knowledge of Russian, but the curricula of university courses was a matter for the universities themselves. These institutions were conscious of the need for Russian courses suitable for scientists and an increasing number of such courses were being provided at most of the major universities, and at quite a number of technical colleges. The supply of teachers could only expand gradually, but the universities would make every effort to see that the supply did expand as far as possible.

Advances in Helicopter Construction

Mr. Arthur Woodburn (Labour) asked the Minister of Supply about recent progress in the construction of helicopters. He pointed out that the British aircraft industry was approaching the point of producing machines capable of economic inter-city transport and urged that prompt and adequate assistance now could give Great Britain the lead in this development. Mr. Aubrey Jones said that his ministry had been largely responsible for this progress. He had indicated to the companies concerned with the development of the most advanced machine in this field, the Fairey Rotodyne, that the Government were prepared to continue to support and contribute to its further development. He was now awaiting the firms' financial proposals.

New Cable Ship

A decision has now been reached regarding the building of a new cable ship for the Post Office. Mr. Ernest Marples, the Postmaster-General, told Mr. C. R. Hobson (Labour) that his department hoped to place an order for a new ship before the end of the current year.

Scientific Attaché for Moscow

In reply to a question by Mr. Bernard Braine regarding a scientific attaché for the British Embassy in Moscow, Mr. Harmar Nicholls agreed that it was proposed to make such an appointment. The duties of the attaché would be to advise our ambassador on scientific matters, and to report on scientific technical research and development in the Soviet Union.

Television in Kent

Mr. Ernest Marples told Mr. George Darling (Labour/Co-operative) that an experimental low-power satellite station is to be installed by the British Broadcasting Corporation at Folkestone during the next few months, and that it is expected that the new station will serve about 40,000 people. If the experiment is successful, the B.B.C. will consider applying the system of low-power satellite transmitters to other parts of Britain.

A Trade Fair in Peking?

The Federation of British Industries are investigating the possibility of holding a British trade fair in Peking. Mr. F. J. Erroll, the Parliamentary Secretary to the Board of Trade, told Mr. S. S. Awbery (Labour) that the Federation had been informed that the Government would give their support if the fair was held, but it was realised that some firms might not wish to take space for exhibits pending the outcome of the review of the control lists now proceeding in Paris. The Board of Trade was doing its best to expedite that review, but many governments were involved and it was bound to take a little time.

European Free Trade Area

Negotiations for the establishment of a European Free Trade Area were referred to by Mr. Henry Hynd (Labour), when he asked for a report on the progress which was being made in this matter. He pointed to the importance of the time factor and wondered whether the Government were pursuing the negotiations with a sufficient sense of urgency, having regard to the fact that the common market began to operate at the beginning of this year and that the tariff reductions would commence to operate on 1 January next. Mr. Reginald Maudling, the Paymaster-General, replied that the Government were awaiting the document which the six countries of the European Economic Community were preparing on the basis of the French proposals. In the meantime, useful work was proceeding on a number of important details.

Companies in the News

I.C.I.'s Policy of Expansion

The chairman of Imperial Chemical Industries, Sir Alexander Fleck, told his company's shareholders of a worsening in trading conditions and held out little hope of an increase in turnover during the current year. Despite the group's widespread coverage of industrial activities in this country and in all our principal overseas markets—no company supplies a wider range of industrial materials—Sir Alexander found it difficult to be definite in his predictions. " For the first few months of 1958," he said, " home sales turnover has not been unsatisfactory" but conditions during the same period in export markets have become " considerably more difficult." This, he explained, was partly due to the tightening up of import restrictions and to the major uncertainty of developments in the United States. He pointed out the twin dangers of inflation—which he underlined as the major threat to the continued successful expansion of British industry—and of a recession.

The most heartening message for shareholders concerned I.C.I.'s long-term policy of expansion and the confidence the chairman expressed in his company's ability to carry this out. He pointed out that there had been a steady change in the pattern of operations and that turnover and profits from new products were increasing. Engineering firms will draw considerable satisfaction from Sir Alexander's statement on I.C.I.'s capital expenditure policy: " We shall continue to spend capital on the erection of new plants, or on the extension of existing plants, not with an eye on the demand in the next few months but rather with a faith in the long-term trend of demand for our products." This, he said, would make " a modest, but significant, contribution to the stability of demand for the products of other British industries."

This enlightened outlook is the best assurance against a slump. Were it widely shared in industry there would be no recessions, nor inflationary periods, for long-term planning of steady expansion—coupled to a live awareness of the changing pattern of demand for the products we make—provides a steadiness no Government action can induce.

Dravo of Pittsburgh

The activities of the Dravo Corporation, Pittsburgh, Pennsylvania, are an interesting example of growth from contracting into plant manufacture, shipbuilding and latterly nuclear engineering. Turnover in 1957 was 109 million dol, the highest in the company's history, but orders booked were substantially below the record level of 1956 and the backlog fell from 115 million dol to 72 million dol. The decrease in business was attributed mainly to " a reduction in capital expenditure by industry."

The company's prospects in their traditional fields—contracting, structural engineering, shipbuilding, crane and other heavy steel fabrications and power station plant and equipment—were not good, in line with the rest of United States industry. The chairman of the board, William K. Fitch, and the president, Carl B. Jansen, indicate in their report that most of the brighter side is being provided by progress in new fields: they erected the nuclear portion of the first full-scale commercial power plant in the United States which has gone into service at Shippingport, Pennsylvania (see p. 682). Activities in the sinter plant field and other new product lines were described as " promising." The comment that although " already well diversified, we recognise the desirability of further expansion under proper conditions," illustrates how, in the United States, as in this country, widespread activities over all major sections of the economy is the key to industrial stability. Dravo's considerable progress in the metallurgical, chemical, and nuclear engineering fields is a good example —showing wise anticipation—of effective action against a slowing down of expansion in conventional activity.

This policy requires immense capital resources. In the past ten years they have invested 32 million dol in property plant and equipment (5 million dol in 1957), and working capital requirements have increased 167 per cent since 1947 to 14 million dol. Nonetheless, the company are currently performing much above average in the United States, and it may well be that there is little alternative to their policy of diversification and large-scale activities if growth is to be sustained.

Balancing Locomotives

Few large builders of locomotives have fared so well as Beyer, Peacock and Company during the past few years. The results for last year fulfilled the chairman's forecast and the group trading profit amounted to nearly £580,000. Mr. Harold Wilmot told shareholders that the group's policy of diversification had made good progress. Demand for the company's articulated steam locomotives has been well maintained and Mr. Wilmot considers that " for some years to come there will be special services for which steam in its most modern form will remain supreme." Nonetheless, these special cases " are bound to grow fewer " and the company are therefore continuing to expand in other directions.

Bearing in mind the likelihood that electricity generated in nuclear stations may eliminate many of the economic advantages of steam bulk haulage, the group, in collaboration with Metropolitan-Vickers, formed in 1949 a company to handle the interests of both companies in electric and diesel-electric traction. Another company, Beyer Peacock (Hymek) Limited, was formed recently with Armstrong Siddeley Development Company to exploit the demand for diesel-hydraulic and diesel-mechanical locomotives. The group will thus have an interest in all forms of rail traction and will be allied to two of the most powerful groups in engineering—A.E.I. and Hawker. In addition they have developed their interest in the production of agricultural machinery and, to quote the chairman, demand " continues to expand and sales are now at very satisfactory levels."

The group's other interests—in machine tool manufacture and systems of construction—have recently been swelled by the acquisition of the Anti-Attrition Metal Company. It is the group's policy to go on with expansion and the broadening of the basis of operations " in a logical way so as to avoid, if possible, the more severe effects of demand fluctuations in any one product." Mr. Wilmot's remark that the conservative financial policy of the board proved very valuable—" we had no borrowing problems. On the contrary we were able to help customers facing financing problems as a result of the credit squeeze "—is probably quite unique among the company reports published in this year of capital shortage.

Asbestos in the Ascendant

The annual reports of the Cape Asbestos Company Limited and Bell's Asbestos and Engineering (Holdings) Limited show that the consumption of asbestos products has increased considerably during the past year and is continuing to increase at a high rate. The chairman of Cape Asbestos, Mr. Giles Newton, reports that the results for the first three months of 1958 " approximate to those of the corresponding period in 1957 " and that the group's factories have substantial contracts in hand. The output of their mines remains in heavy demand. Mr. C. W. Bell, chairman of Bell's Asbestos, states that his confidence in the group's strength is " unshaken " and that " the potentialities are there." Although Bell's profits fell by some £80,000 to £782,300 in 1957, expansion is continuing and an additional 30,000 sq. ft of new buildings will be occupied by the middle of this year. Cape's profits (after all charges except tax) rose to £1·42 million from £1·25 million in 1956. Mr. Newton attributes this substantial increase to " the vigorous prosecution " of a policy of expansion and re-equipment of their mines.

Asbestos is finding new outlets and there has been a large increase in the sales effort made by both companies. Cape report a " very healthy " increase in turnover over 1956 which made it possible to maintain profit margins despite rising costs. Mr. Newton draws attention to the fact that their high temperature insulation has found extensive application " in both nuclear and conventional power stations."

The vast increases that have been made in productive capacity and in mining facilities for asbestos products has not so far led to any significant surplus. There are competing materials—plastics, glass fibre and others—but the trend is unmistakably for more insulation and the conservation of heat. The prospects of asbestos producers thus appear to be better than those of most suppliers of industrial materials.

Propellers Into Fans

Diversification in the aircraft industry has been recently discussed in ENGINEERING (for 9 May), mainly in relation to the principal airframe and aero-engine manufacturers. In the aircraft-component and accessory field there are, of course, many more manufacturers who have branched out into other fields. A typical example is the Airscrew Company and Jicwood Limited, a firm whose payroll is numbered in hundreds rather than thousands. Prior to the second World War, their interests were concentrated mainly on wooden-blade propellers for aircraft, production reaching 800 propellers a week—quite an achievement in view of the amount of skilled handwork that goes into a wooden propeller. After the war, with the demand for propellers decreasing sharply, this led the Airscrew Company naturally into the hardboard industry—they are now well-known for their Weyroc, Weydec and Hardec products.

To-day, the demand for wooden-bladed aircraft propellers is restricted to small aircraft; increasing engine powers demanded large metal-bladed propellers and, in turn, these are increasingly superseded by turbojets. But as the demand for propellers has diminished with increasing aircraft power and speed, so has the demand for cooling fans grown within the aircraft industry—for cooling accessories, electrical and electronic gear, and cabin air-conditioning systems. Among the aircraft that have used, or will use, the company's fans are the Comet 4, Viscount and Viking airliners, the Dragonfly and Wessex helicopters, the Beverley troop carrier and the Victor bomber.

Concurrently they have developed a wide variety of industrial fans, of both the axial-flow and centrifugal types. Many British wind tunnels are driven by Airscrew fans. Laminated hardwood impellers for cooling towers—from 6 in to 26 ft diameter—are exported. One of their most important developments is the adjustable pitch and detachable-blade range of axial-flow impellers. The construction of these impellers allows for the adjustment of pitch, diameter and number of blades during manufacture, making possible a wide range of performance from a small stock of basic components. The company are currently making rapid headway with a sales campaign for this " A.P.D.B." range of impellers among fan manufacturers in the United States and Canada.

We regret that, in our issue of 16 May, p. 617, we incorrectly described Mr. W. Lionel Fraser as being the former chairman of Babcock and Wilcox Limited. Mr. Fraser is still chairman of that company, as well as of the Tillings Group as we correctly stated.

Atomic Review

Shippingport Reactor

THE Shippingport nuclear power station, America's first large-scale one for making civilian electricity, was inaugurated on 26 May. Its primary purpose is said to be to advance the technology of pressurised water reactors rather than generate electricity economically, and it will not operate to give continuous power at a maximum load factor.

The project was under the supervision of Rear Admiral H. G. Richover, chief of the naval reactors branch, USAEC, and it is expected to give data for reliable cost estimates for this type of equipment. Construction of the reactor plant began in the spring of 1955, by the Westinghouse Electric Corporation under contract to the AEC. The Duquesne Light Company, of Pittsburgh, built and own the generating facilities—the result of an agreement in March 1954. They provide the site and generator capacity up to 100 MW, which they privately pay for. During a five-year period from last December, they will buy 11 million dol worth of steam at 8 mills per net kWh.

The reactor went critical on 2 December—the fifteenth anniversary date for Fermi's Chicago pile—produced electricity 16 days later, and reached full load on the 23rd. It is the biggest nuclear plant in the world operating solely to produce electricity. The 160 ton pressure vessel was put in place in October 1956, and the core a year later.

The main design features are:

(1) A net output of 60 MW, using steam at 600 lb per sq. in.

(2) Cooling with ordinary water at 2,000 lb per sq. in.

(3) The core should last 3,000 hours at full load.

(4) Refuelling should involve a minimum of shut down.

(5) The control system is as simple as possible.

(6) Commercially available equipment was used wherever possible.

(7) The operating cost is to be a minimum, allowing for the above requirements.

Estimated Costs

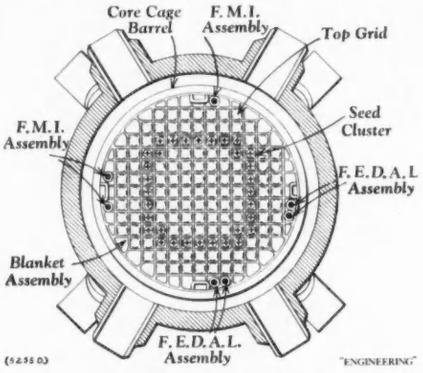
Overall costs for the p.w.r. plant, estimated in January, were 121·4 million dol of which 98·4 million were Government funds, 22·5 million were from Duquesne, and 0·5 million from Westinghouse. Further details are given below, and if, as is expected, the plant eventually operates at more than 60 MW, then clearly the cost per kWh unit will fall.

The nuclear plant construction cost totalled 55 million dol, mainly Government funds, 5 million coming from Duquesne and 0·5 million from Westinghouse. The whole of the 17·5 million dol turbo-generator plant costs came from Duquesne, while all the research and development costs of 48·9 million dol were governmental, up to December last.

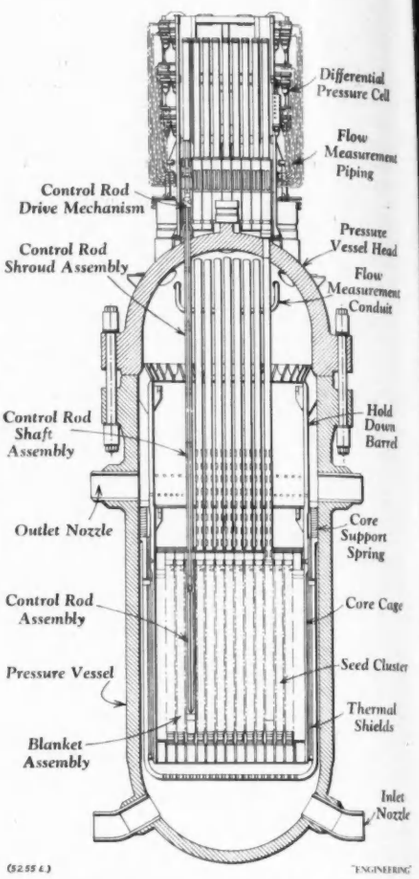
Power costs are estimated at somewhat over 64 mills per unit—made up from 22·7 ex-capital investment, 43·4 from fuel and 3·3 from operational cost—a fuel credit of 5 being allowed. Power is produced equally from a seed core (enriched fuel) and a blanket (natural uranium oxide), the latter having a lifetime of 8,000 hours. Two seeds will be needed, the first lasting 3,000 hours.

Annual fixed charges are based on 14 per cent of the capital cost, which allows 2 per cent for local taxes, 1 per cent for insurance, etc., and 11 per cent for normal financing, income tax, depreciation and dividend, giving amortisation in 30 years.

The blanket contains 14·6 tons of UO_2 at 40·5 dol per kg and the seed 182 kg of fuel at 16,000 dol per kg. The total fuel cost, fabricated, is 20·8 million dol. A gramme of fissioned uranium 235 gives approximately a megawatt day of reactor heat. Plutonium credit is 12,000 dol per kg and the final blanket content of uranium 235 is assumed to be 0·43 per cent, the actual burn-up in both parts of the core being 38·5 kg. One hundred and thirty men will run the station at an average pay of 450 dol per month.



The plan section of the reactor shows the position of the flow metering installation and the failed element detection and location system.

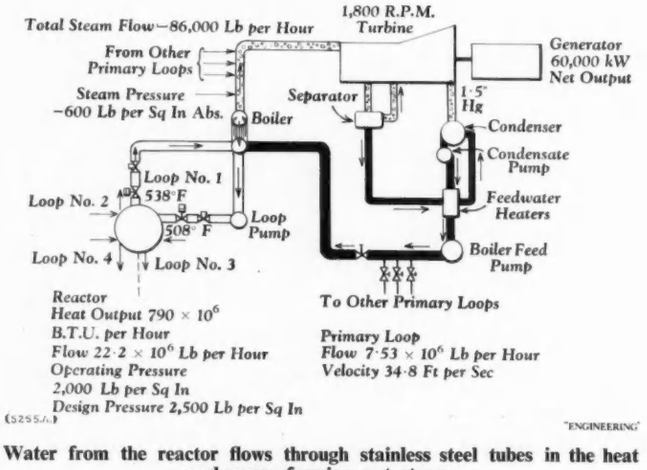


When the reactor is operating, the upward hydraulic thrust exceeds the weight of the components.

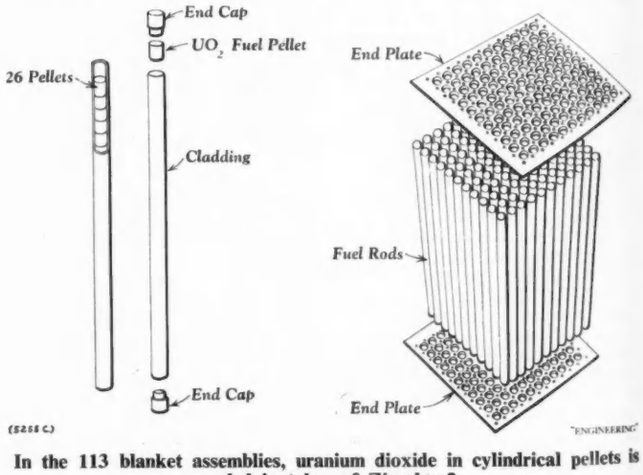
Design Philosophy

The original concept had been for slightly enriched fuel, but this changed to a seed-and-blanket combination with highly enriched and natural uranium, with the longest possible fuel life—an initial goal being to exceed 3,000 thermal megawatt days per ton. The p.w.r. design was chosen as the only proven power producer in 1953—the steam pressure being a compromise between efficiency and reactor cost.

A multiple loop system is used, with spare capacity to ensure high reliability as well as keeping pipe, pump, boiler and valve sizes down to normal commercial levels. Although four loops are used, the pumps needed are four times larger than any previously built of that type.



Water from the reactor flows through stainless steel tubes in the heat exchanger, forming wet steam.



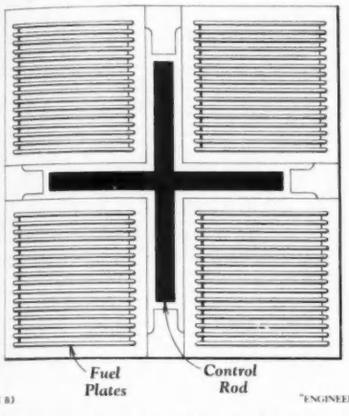
In the 113 blanket assemblies, uranium dioxide in cylindrical pellets is sealed in tubes of Zircaloy-2.

Only three loops need be used, the fourth acting as a spare.

The constant average coolant temperature idea was accepted because it gives easier reactor control and maximum advantage can be taken of the negative reactor temperature coefficient. This does give a variation from no-load pressure of 834 lb per sq. in to full-load of 600 lb per sq. in, necessitating some increase in steam plant cost.

Interesting points regarding the coolant system include:—

(1) Hermetic sealing to increase reliability and reduce possible contamination, using canned motor pumps and control rod drive, sealed valves and instruments.



Enriched fuel elements have a cruciform channel for a control rod.

(2) Corrosion resistant metals to minimise radiation problems, e.g. stainless steel throughout except for zirconium in the core and bronze in the low temperature portions.

(3) Failure of a few fuel elements would not necessitate shut down as the failed elements need not be removed for months.

(4) All pipes contain automatic or remote control isolation valves as close to the vessel as possible.

(5) All parts contacting the coolant were especially clean. The radioactive part of the vessel is surrounded by 3 ft of water shielding, with concrete near personnel access areas. The reactor vessel container thickness varies from 0·66 to 1¼ in and the concrete surround from 3½ to 5 ft. Wherever codes existed, the plant complied with those of the American Society of Mechanical Engineers and the Commonwealth of Pennsylvania.

For the reactor itself some considerations are:—

(*a*) Core instrumentation allows measurement of fuel and coolant temperature and of flow rate, as well as incorporating a failed fuel element detector and locator.

(*b*) Failure of one fuel element must not cause its neighbours to fail; the fuel is removable piece by piece through ports in the pressure head, or entire—as a cartridge—if the head is removed. Fuel assemblies can be reshuffled if desired.

(*c*) A minimum of mechanical fasteners and simple design was used, with a one pass coolant, the pressure vessel head being a significant contribution to reactor technology.

(*d*) It can be shut down if one control rod sticks and both dry and wet refuelling can be compared, the element design being suited for low cost manufacture.

The pressure vessel has ten access ports for handling fuel without removing the head, and will withstand 2,500 lb per sq. in, although normally operating at 2,000. Thermal shielding with coolant prevents undue thermal stress from radiation on the vessel walls. An underwater television camera can be used for monitoring. The size was set by the core size (6 ft cylinder) and wall thickness of 8¼ in by reasonable estimate of practical limit of fabrication.

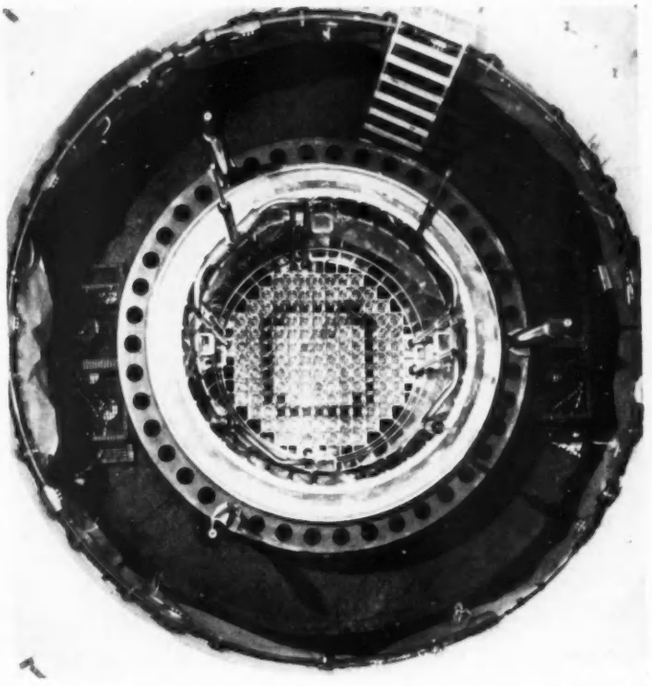
The reactor and heat exchangers are mostly underground, wherein cylindrical is the most economic shape, with the boilers somewhat higher to give natural convection even if the pumps failed.

Fuel Arrangement

One hundred and forty-five assemblies are used, 32 of them being enriched and having a total of 165 lb uranium 235, the blanket totalling 198 lb. The seed is arranged in a hollow square and needs some reflected neutrons from the blanket for criticality; being small in area, it needs a minimum of control rods.

The pressure vessel is of carbon steel ASTM-A-302 Gr.B., clad with 304 stainless and, exclusive of projections, is 32½ ft high with 10½ ft outside diameter. Coolant inlet nozzles are near the bottom and outlet ones in the middle, with a baffle or flow guide near the bottom of the outer thermal shield to give 15 per cent of the flow to cool the two stainless steel shields, before reaching the core. A ledge supports a shield flange and the core, which is in a core cage —essentially a bottom support plate, barrel and top grid with locking grooves.

The fuel, as zirconium alloy in Zircaloy-2 sandwiches, has an active length of 70 in and forms into square assemblies, 6 in apart on centres, with cross shaped control-rod channels. Forty-five of the Zircaloy blanket tubes, containing 26 oxide pellets, are inside the seed core square. Blanket rods are 10 in long by $\frac{43}{128}$ in formed into seven bundles of 120 rods each, stacked upon each other with space for an eighth. Outlet ends of the blanket assembly contain sampling rakes which lead to external radiation detectors.



The top view of the reactor shows the arrangement of the monitoring loops.

Thermal Design

The reactor produces 790 million B.t.u. per hour or 231 MW of heat at an average coolant temperature of 523° F. There must be no local boiling at the hottest core parts in steady state operation, thus the fuel surface temperature must be below 636° F; for operation, adverse instrument errors of 30 lb per sq. in and 5° F are assumed. For three-loop flow the following parameters are expected:—

22·7 million lb/h coolant flow at an inlet temperature of 507° F and an outlet of 538° F. The seed heat transfer coefficient in B.t.u./h-sq. ft °F is 9,060; for the blanket it is 5,890.

The steam generators give a flow of 860,000 lb per hour to an 1,800 r.p.m. turbine of 100 MW rating, the condenser being at 0·74 lb per sq. in and cooled from the Ohio river. The house load of 8 MW comprises 5 MW for the nuclear part and 3 MW for the turbo-alternators. Each loop has a heat exchanger steam generator, two being straight tube types by Foster-Wheeler and two U-Bend Babcock and Wilcox equipment.

Steam System

Water heated by the reactor flows through hundreds of small stainless steel tubes in the steam generator heat exchanger, forming wet steam—the moisture being removed. A maximum of 1,340,000 lb per hour of dry saturated steam is delivered to the two turbine throttle valves at 486° F, via a pipe system containing relief, check and stop valves.

At the turbine, steam conditions vary from 865 lb per sq. in at no load to 570 lb per sq. in at 60 MW net. The single cylinder turbine has a last row blade 40 in long, and has three points of extraction for feed water heating. Stellite strips protect the inlet edges of blades having top speeds over 900 ft/s. The condenser has 10,280 tubes with 70,000 sq. ft of cooling surface, with auxiliaries including two 59,000 gal per min mixed flow circulating pumps.

Deaerated make-up water, up to 6,000 gal per day, can be supplied demineralised, at up to 15 gal per min, and two water samples are drawn from each boiler, continuously at 1 pint per min to check for tube leaks. The station can operate automatically over 20 to 100 per cent full load at an average rate of change of 3 MW per min and accept load swings of 20 MW at 25 MW per min.

Safeguards

All possible accidents which might release radioactive materials through any of the barriers have been evaluated. An explosion in the reactor would give no hazard of any type beyond the site.

There are two barriers between fission products and the surround, separately continuously monitored. The fuel is in corrosion-proof alloy, the coolant in a closed pressurised container, and the entire reactor plant housed in a gas-tight steel pressure vessel. Apart from points already considered, e.g., loss of electric power, pump or coolant flow failure, release of all the coolant to atmosphere will give no biological hazard at the site boundary, even at the end of core life with 1 per cent blanket element failure.

Complete loss of reactor coolant through a major rupture is the only accident which could give sufficient amounts of fission products in the container, and even then the safety injection system could pump in enough water to prevent core melting, with one exception. If a rupture larger than 6 in diameter occurs in the coolant system below core level and near the reactor, some core meltdown, zirconium-water reaction, and fission release to the container may occur. Up to 20 per cent of the blanket could melt, which could give up to 1·4 per cent of the total activity release to the container.

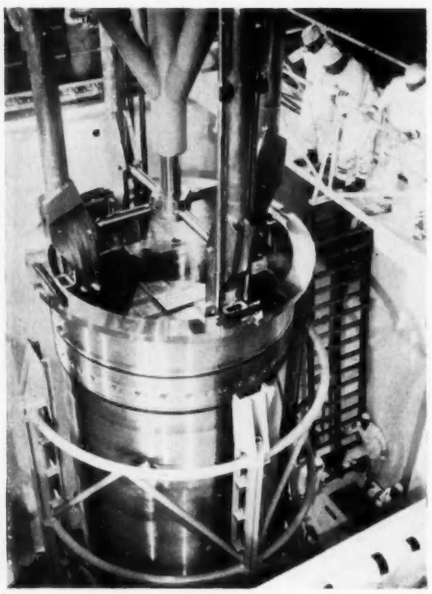
Continuing Atomic Review

In this case 4·5 per cent of the 9·38 tons of zirconium could react with steam and give a self-propagating fire a few minutes after rupture. The container can withstand any pressure developed. If the hydrogen formed mixes uniformly with the air and steam no burning or detonation will occur.

Radiation

Three systems of radiation reporting are used:

(1) *Operational Monitoring.*—This has 12 channels, with computer indicators to give read-out information in the control room. Six types of detector are used. Four sample steam water, four monitor the boilers, one monitors pump coolant, etc. Others check



Core being lowered into reactor vessel by means of an alignment jig.

container cooling air, and the limited access cubicles.

(2) *Background Monitoring.*—This includes on and off-site equipment of the most varied type.

(3) *Waste Monitoring.*—Fourteen detectors in four channels monitor activity levels in liquid and gas hold-up tanks, evaporator and effluent channels.

Chemistry

To suppress formation of oxygen from dissociation of water under radiation, 25 cc of hydrogen per kg are maintained in the coolant. Corrosion is inhibited by raising the alkalinity to between 9·5 and 10·5 pH with lithium hydroxide, which is automatically maintained via an ion exchange resin by-pass.

Tests showed that with oxygen absent, uranium dioxide is chemically stable in non-acid water—and that failure of one fuel element did not lead to progressive failure of any contacting neighbours. Fission products released consist of halogens, noble gases, alkali metals and alkaline earths; but plant can be made accessible in most cases by use of ion-exchange purification—the same technique also being used for waste disposal after decay in storage. An irradiated loop was decontaminated in test and returned to service, and the coolant is constantly monitored for hydrogen and oxygen levels.

Waste Disposal

Radioactive waste discharged into the Ohio river or the atmosphere will be a small fraction of the maximum permitted by the AEC and NBS (Handbook 61); in operation the level should be less than 1 per cent of those limits. Released material meets the requirements in Codes of the Commonwealth of Pennsylvania; and the United States Public Health Service, Pennsylvania Department of Health, and Ohio River Valley Sanitary Authority were consulted.

All tanks or burial facilities are protected against leakage to ground, by watertight concrete enclosures which have sumps for system leak removal, vapour being contained. Radioactive gas can be stored during maximum temperature inversion conditions, for example, five days. United States Interstate Commerce Commission Regulations, 1956, parts 71-78, cover handling and shipping hazards for packaged wastes—and spent fuel elements will not be processed on site.

Solid wastes such as paper, rags, clothing, when contaminated will be burnt—the gases being scrubbed and filtered, the ash and wash water being slurried and stored. Contaminated tools, metal and small equipment are put in 30 gallon drums and sealed, then put inside larger drums and concrete poured between the two shells, the final package being dumped at sea. Large pieces of equipment can be handled by remote control and buried in a site graveyard.

Site monitoring started in 1956 and evaluations are being made of the soil around the plant, of the Ohio river above and below the area, well water within a mile, vegetation, and the atmosphere.

Notes and News

Antarctic Uranium

Dr. Tatsua Tatsumi, who was with the Japanese party wintering in Antarctica last year, reported recently to the Japan Science Council on his return to Tokyo that he had discovered radioactive rock around Showa Base on Omgul Island. One location was at a point 50 miles south of Showa Base on the Lutzow-Holm Bay where he found rock containing 40 to 50 per cent of oxidised uranium. In another place 25 miles south of Showa Base, pitchblende rock with the same uranium content was also found.

Agreement with Italy Ratified

In London on 12 May Foreign Secretary Selwyn Lloyd and Italian Ambassador Vittorio Zoppi ratified the Anglo-Italian ten-year atomic energy agreement which was signed last December. It provides for the supply of both power and research reactors with the necessary uranium fuel, the exchange of unclassified technical information between the two countries, the possibility of assistance from this country for the construction in Italy of plants for the manufacture of fuel elements and for processing used nuclear fuel, and provision of training facilities for Italian scientists in Britain. The agreement contains safeguards to ensure that material and equipment cannot be used to make weapons. It is the first agreement signed by the United Kingdom which is directly based on the supply of uranium fuel for nuclear power stations. The Anglo-Italian agreement takes into account the fact that Italy is a member of the six-nation European Atomic Energy Community (Euratom). Accordingly, any rights ceded to Italy under the agreement would apply to other members.

Industrial Agreement for Pressure Vessels

Atomic Power Constructions Limited and Babcock and Wilcox Limited have announced that in August, 1957, they completed an agreement whereby Babcock and Wilcox Limited would undertake detailed design, manufacture and erection of the reactor pressure vessels forming part of nuclear power stations to be supplied by Atomic Power Constructions Limited and their member companies, Crompton Parkinson Limited, International Combustion (Holdings) Limited, Richardsons Westgarth and Company, Limited, Elliott Brothers (London) Limited, The Fairey Aviation Company, Limited, and Nuclear Civil Constructors.

Babcock and Wilcox will also supply any special heavy duty crane required by Atomic Power Constructions Limited for the erection of pressure vessels, heat exchangers, etc.

The Human Element

MECHANICAL BUSINESS

A conference accompanied the recent Instruments, Electronics and Automation Exhibition. In one of the papers, "Computers and Numerical Automation," it was suggested that in 20 years business letters would be handled by machines and rarely by human executives.

The author, Dr. A. D. Booth, director of the Birkbeck College computation laboratory, University of London, was considering contemporary developments in machine translation of language, and the recognition of spoken sounds by a machine. "I would say that some time within the next ten years we will have the following change. The computing machine is the centre. There will be a device into which one can speak and which will enable the computing machine to recognise the spoken expression one wants. Next there will be a device which, as a result of analysing the contents of the human speech at the input, can initiate suitable outputs to answer business correspondence. Most of you would probably be prepared to admit that business letters are by and large of a stilted character. There are one or two elementary divisions in the morning mail. In these divisions the letters are in standard form. The machine can do this quite well and recognise what we say about the nature of the morning's correspondence. "Dear Bloggs, I regret you have not paid your bill for six months" would be a perfectly standard noise, and the machine then reads out a perfectly standard reply prepared by the legal department of the firm.

"This is one application we shall see in perhaps the next ten years. But I'm afraid they do not end there. The machine of the future will be able to recognise, we hope, the printed word on a large scale, which means that instead of an executive reading his mail he will pass the letters into a machine which will read them, analyse their sentiments, make certain decisions and give back an answer. If any high level decision is wanted, the machine will throw back the letter and say 'This is the one letter for the week that you have really got to look at. You can go and play golf the rest of the week. This one I can't decide.' You may think this quasi-humorous, but if you want me to guess I would say that within the next 20 years business correspondence will be presented to a machine directly to be dealt with by the machine, and only in selected instances will the human executive be called on to take action."

"This," continued Dr. Booth, "leads us to yet another thought—that the machine will become the Big Brother of the future. In case you think this is too fanciful I ought to mention that the National Physical Laboratory has been giving great thought to this matter, namely, a cradle-to-grave record of every person in these islands." He went on to point out that machines are now capable of taking over much of the classical office operations in industry, such as office accounting, pay rolls and accounts, and possibly some of the economic and strategic planning of the firm's operations. One could, he said, conceive of a firm possessing a machine which would answer its incoming mail, consult the appropriate records and give the reply, apart from taking difficult and intricate decisions. Obviously if all firms were using machines to make their decisions it inevitably led to the abolition of firms' entities and complete economic control by large data processing machines.

"I shall not try," he said, "to make a guess at the time scale of such a development. We profoundly hope it will never happen. Machines can be quite inhuman devices, and there are many decisions which have to be made on the basis of sentiment and not on the hard facts of life."

Continuing **The Human Element**

No Joint Council for the Industry

Engineering and shipbuilding employers have again rejected the suggestions made by the Court of Inquiry in 1954, and repeated by the Courts of Inquiry for both industries in 1957, that a National Joint Council should be set up. The Minister of Labour, Mr. Macleod, announced this in the House of Commons last week and expressed his regret that nothing more positive should have emerged. But, he said, " it is, of course, for the organisations themselves to agree upon machinery for the discussion of wages and other conditions of employment, as well as matters of joint interest affecting the productive efficiency of the industry."

The main reason given by the Engineering Employers' Federation for rejecting the proposal was that they had reached the conclusion that the suggested joint council " would not achieve the result desired by the Court of Inquiry." The Shipbuilding Employers' Federation found themselves unable to agree to the proposals in the report and consider that existing arrangements within the industry should continue to operate.

There have been many precedents, some most successful, for setting up joint councils to keep under constant review the basic problems of the industry concerned. Those for the motor, machine tool and power plant industries are examples of effective working. But the bringing together of employers and unions under Government chairmanship was unlikely to appeal in industries where the unifying theme is relatively weak, each section having its own separate set of problems. Only the broadest aspects of policy, such as full employment or wage levels, could have been considered and this, presumably, the employers prefer to deal with themselves.

Markets or Men?

" Men, Women and Work " was the subject of the E. W. Hancock paper on " Human Relations in Industry " at the third production conference organised at Olympia by the Institution of Production Engineers. Mr. L. Wright (chairman of the British Productivity Council) was the speaker. In the course of his talk he raised once more an old and complicated controversy. It may be summed up in the phrase: which should be the criterion of action in management —the social or the economic situation?

The fact is that those on both sides of the argument have tended to confuse the issue by putting their own case too strongly at the expense of the other. There are times when the economist is right. For example, it is useless to blame bad training, or lack of ability on the part of a salesman to adjust himself to his environment, if his competitors can do no better owing to bad business generally. Yet this often happens. On the other side, it is wrong to assume that money incentives are the key determinant to attitude to work. Many, however, conduct their managements as if they were. The fact is that it is as wrong and dangerous to ride any one hobby horse in economic and social matters just as it is in any other issue.

Our Proper Stations

An American magazine recently succeeded in stirring up a lively correspondence in its columns by printing a photograph of a group of executives who had been issued by their company with blazers as a sort of uniform. The correspondence was hostile—and rightly so.

Uniformity is a good thing if it confers self-respect, enforces discipline where discipline is necessary or merely accedes to a harmless fashion. The postman, soldier and City " gent " are examples of each. Carried too far it becomes tedious and even dangerous. There are various manifestations of this kind of thing. Among them are grades of executives wearing different coloured badges in their button holes, and office rules which may be broken with impunity by persons of a certain degree of seniority, but not by others.

Such practices encourage petty snobbery (without the values which the milder forms of snobbery may have), jealousy and petty emulation leading to empire building. When carried too far they are a sign of either slipshod management or some busybody not being able to leave well alone. Differences of grade and position there must be in any organisation but human beings are best not encouraged in flaunting them. To put it cynically, it may be necessary to accept the fact that a man gets on by scrambling over the shoulders of the men below, but he should not be encouraged to keep his feet in their faces once he has reached his loftier station.

Straining at the Leash

The annual conference of the Electrical Trades Union held last week at Morecambe found the delegates in a militant mood. The words " industrial action " were being uttered on every pretext, including such issues as pensions and housing. The leaders found themselves in the unaccustomed role of moderators on a number of occasions, including the call for " something more substantial than resolutions and donations " in support of the London busmen's strike. One delegate argued that the least the ETU could do was to call out members supplying current to the underground. But Mr. F. L. Haxell, the general secretary, spoke against any precipitate action, and none was taken.

On the last day, however, the executive accepted a resolution to call on the TUC and the Confederation of Shipbuilding and Engineering Unions to conduct a campaign against " the Government's and employers' policy of deliberately creating unemployment." It followed a resolution reaffirming the Union's opposition to any form of wage freeze and assuring backing for " appropriate action, including strike action if necessary, to ensure that our living standards are maintained." A strange and discouraging attitude to the most realistic and effective action yet taken by a Government in Britain to keep up the value of money by keeping prices down.

This opposition to the Government is in line with the attitude taken a month ago by the delegates of the Amalgamated Engineering Union at their annual conference. Both are members of the Confederation which is unlikely to take a much different stand when it meets.

Unrest around London

The spread of the London dock strike before the Whitsun week-end and the failure of the Government's conciliatory moves in the bus strike do not augur well for the peace of London in the coming weeks. Yet the general atmosphere could not be more conducive to a settlement of the bus dispute. Only a little strong feeling appears to have been aroused, there has been no violent clash and no undue recriminations on the public's part. In other words, the strike has not followed the normal pattern of making a bad situation worse. The fact that a settlement seemed after 19 days to be as far off as ever suggested that a great deal more was at stake than busmen's wages.

The dock strike began as a sympathy strike with the Smithfield porters and spread because, according to the dockers, outside labour was used to unload certain ships. Some 8,500 men were out at the end of last week with every likelihood of a more complete stoppage. At a national conference called in London last week to consider the rejection of their claim for " a substantial wage increase," some of the dockers' delegates called for strike action, but the conference eventually passed a resolution leaving the precise nature of the action to be taken to their negotiating committee.

The dockers and the busmen belong mainly to the Transport and General Workers' Union. Mr. Frank Cousins has been very firm in his talks with Sir John Elliot, chairman of the L.T.E., and during their joint meeting with Sir Wilfred Neden, the Ministry of Labour's Chief Industrial Commissioner. Funds are being collected for the busmen and there is talk of increasing strike pay. In some quarters, talk of the bus strike as the Unions' challenge to the Government's policy of deflation was still being heard and sympathy strikes were still being considered.

Teachers on Pension

The sad story of poverty among the retired teachers of Kent was told at the annual conference of the National Association of Head Teachers by Mr. J. W. Watts, a member of the Association's council. Few had enough money to replace clothes, feed properly or have their homes redecorated. " They have to think," said Mr. Watts, " before they can buy a newspaper, take a bus journey, or entertain in a simple way."

A case quoted at the conference of a woman teacher who retired in 1940 after 43 years' service on £3 4*s*. 0*d*. a week, and who is now getting only £4 15*s*. 0*d*. a week, illustrates the acuteness of their misery. A resolution was passed instructing the council to " take immediate steps to secure a pension scheme which will automatically gear retired teachers' pensions to current salary scales and to any future improved salary scales." They have a strong case—they pay a stiff premium —and so have the multitude of other professional people who exist on fixed pensions.

Educators and Brick Walls

It is the right of every vested interest, using that phrase in an enlightened sense, to indulge in special pleading. If they do not do so, who else will? When it becomes over-insistent, however, it shows that those concerned are determined to wish away the problem. In this category comes much of the propaganda, even of the better sort, put out by educationists and teachers.

A recent example of such declarations has been Mr. W. Hatton's presidential address to the Association of Teachers in Technical Institutions. He declared roundly that the top priority should be given to a long term investment in the education of the young when allocating the nation's resources. There is always a strong emotional appeal in this argument, for we all like to think that we are putting our children first—especially if it can be done at the taxpayers' expense. But carried too far it is a dangerous argument. Education is a high priority, but it is not the top priority. It would be a simpler world if it could be so. All educational facilities have to be paid for by someone for they are a draft on the community's resources. They are like many other things—a tax on the economy's earnings, and they are entirely dependent on those earnings. The top priority is to keep those earnings high.

A quick solution to our educational problems lies not in sweeping long term changes (important as these may be for other reasons) but on making the best use of what is available. In other words, educationists and teachers should emphasise the value of ingenuity in educational methods. It would help to keep the long term objectives in proportion as well.

Special Article

THE WINDMILL TO-DAY

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The development of the windmill in recent times stems from its association with electricity. This innovation has made it possible for a machine of a given size to produce a far greater amount of useful energy, and so to bring it back into competition with other energy-producing machines. The windmill was first used as a prime mover for the generation of electrical energy just before the turn of the century. Since then various investigators, working in different countries and at different times, have sought solutions to the problems posed by the application of the old prime mover to the production of a new form of energy.

Fig. 1 An English corn-grinding windmill with fantail and remotely-controlled slatted blades for automatic working.

Is it possible that, with the passage of time and the sporadic nature of developments, some of the understanding of the way in which the windmill responds to the wind may have been lost? The "feel of the job" is probably a better way of expressing the knowledge which comes with long experience in close contact with the work. Again, the novelty of the new application may have stimulated designers and inventors to incorporate some entirely new and untried features in the main structure of the machine. Be that as it may, it has been found necessary to gain afresh, during the more intensive investigations of recent times, some general idea of the relation between the wind and the windmill. In this narrative an attempt is made to follow the thread of development of the wind-driven generator to the present day, by examining the construction of some of the more important machines which have been built, both in this country and overseas.

It is not out of place, before proceeding with the main argument, to make a brief survey of the evolution of the old grinding and pumping windmills. For it is now clear that the general principles used in the construction of the power-producing components of these machines are still being applied to-day. Again, it cannot be denied that these windmills embody a considerable amount of hard-won practical experience, so that it may be prudent not to disregard entirely the possibility that there are useful lessons still to be learnt from the construction and use of these machines.

With few exceptions, these machines were built along the following general lines. A number of sails or blades, commonly four in number, were attached to a horizontal shaft so that they were free to rotate in a vertical plane. The shaft was mounted in the top of a tower to allow the blades free access to the wind. The tower and head could be rotated about a vertical axis so that the blades could be brought to face the wind. The main shaft, called the windshaft, was connected through a system of gears and belts to the stones or the water wheel, so that they moved whenever the blades rotated. The first gear in the train was made to accommodate a powerful band brake on its outer periphery. Some of these machines were of considerable size with towers up to 90 ft in height and blades 40 ft long.

The early windmills kept the miller busy. He had to be on hand to run the mill whenever the wind chose to blow, for it was necessary to stop the mill frequently to adjust the cloth which covered the blades so as to match the strength of the wind to the work being done. Also, from time to time, the mill had to be turned into wind.

Then, starting in 1745, a chain of improvements by eminent British engineers, including Lee, Meikle, Smeaton, Hooper and Cubitt, had, by about 1810, completely transformed the operation of the wind-driven corn mill. The machine could now work automatically and so became the world's first automatic factory. The setting of the blades ensured that the machine started running as soon as the wind was sufficiently strong. In high winds, the rotational speed was controlled by opening the slats with which the blades were now fitted, and the slats opened automatically under the pressure of the wind. A fantail automatically steered the windwheel to face the wind (Fig. 1). Inside the mill grain was automatically fed to the stones from storage containers, while the gap between the stones, and perhaps the power which they absorbed, was controlled by a governor to suit the speed of rotation. Finally, an alarm bell warned the miller, who could leave the mill to run unattended, that the grain was running low.

Fig. 2 18 kW direct-current La Cour windmill for local supply. Some hundreds of similar machines with maximum outputs ranging from 5 to 25 kW were in use by 1910. (Denmark)

Fig. 3 15 kW direct-current Darrieus windmill for parallel operation with three-phase alternating-current network through a motor-generator set. (France)

A windmill fitted with these improvements could make greater use of variable winds and, further, the permanent coupling of the blades and the stones ensured that all the energy produced was employed, so that a bigger yield could be obtained on the capital outlay required to build it. It is likely that these complex arrangements for automatic working were introduced, partly, to face the competition of the steam engine, fuelled with cheap coal, which had begun to replace the windmill. But the number of hours in a year which the windmill could work could not be increased, by the use of automatic control, beyond the number made possible by the availability of usable winds, while the steam engine could run continuously.

In England the windmill could not compete and fell gradually into decline, but in other

countries, where fuel was not so cheap or abundant, further improvements to the corn-grinding and water-pumping windmill were being made up to the 1930's. Both Bilau in Northern Germany and Dekker in Holland were concerned with increasing the efficiency of the machine. A considerable increase in the annual running time, and in the maximum power produced, was achieved by covering the blades with sheet metal and by fitting roller bearings to the main shaft. Meanwhile, owing to the scarcity of large timbers, steel members, in the form of a box girder, were being used in increasing numbers for the backbone of the blades, although towers were still being built of timber or brick.

In Denmark developments were taking a different turn. Large windmills had been used, as in England, for centuries, but small windmills, developing perhaps 5 h.p. had also been built in large numbers for individual farms. The increasing demand for power for use on the farms, following the rapid increase in agriculture towards the end of the Nineteenth Century, encouraged the development of the steel windmill. This machine differed from earlier ones mainly in having a simple lattice tower fabricated from standard steel sections.

Fig. 4 100 kW Russian windmill for parallel operation on an alternating-current network.

As the windmill was the principal source of power in agricultural areas, the Danish Government decided to provide financial support for experimental work, which had been initiated by La Cour in 1890. A large machine was then built which had a steel lattice tower some 80 ft high and wind rotor 75 ft in diameter. There were four blades fitted with shutters controlled by a governor, and a fantail was used to head the windwheel into wind. Power was transmitted, through bevel gearing, to a vertical shaft which extended to a further set of bevels at ground level, and the drive was connected, for the first time, to a dynamo. By 1910, several hundred windmills of this pattern, ranging in maximum output from 5 to 25 kW (110 V or 220 V), were supplying villages with electric power (Fig. 2). A storage battery of 100 to 300 AH was usually provided so that light loads could be met for 8 to 10 days during windless periods.

During the first World War, further wind-driven generating plants were built, the largest developing 35 kW from a windwheel nearly 60 ft in diameter. Diesel engines had by this time, however, become cheaper in first cost and also produced cheaper energy than the windmill and battery installation, but their greater use was prevented by the shortage of oil.

The continued use of the windmill as a prime mover depended, then, on the possibility of achieving a substantial reduction in the cost of the energy which it produced. One of the ways in which this could be done was to simplify the construction of the machine. A considerable step in this direction was taken by Darrieus, of the Compagnie Electro-Mécanique, working in France, between 1927 and 1929.

The machines built to the Darrieus design were very simple and deceptively light in construction (Fig. 3). A steel lattice tower supported the head, which was free to rotate, so that the wind rotor, running in the lee of the tower, could be directed into wind by the wind pressure on it. The blades were narrow, allowing a relatively high speed of rotation, and they were quite free of the hinged slats which had been used to control the power output on earlier machines. The generator was located in the head of the machine and it was connected to the windwheel through a gearbox. A brake was mounted on the windshaft. Power from the generator was passed through a set of slip rings, which rotated with the head, and then by cable to the ground.

The principle used to limit the power produced by the blades in high wind had been taken from aeronautics. The flight of an aircraft is possible because the wings produce a force which opposes the weight of the aircraft. For a given size of wing and speed of motion through the air, the magnitude of this force, which is known as the "lift" force, depends on the inclination of the wing to the oncoming airstream. Beyond a certain inclination, however, the lift force drops to a low value due to a phenomenon called the stall.

Darrieus was able to apply this principle to limit the maximum power of his windmills because it is the lift force produced by the blades which gives rise to the driving torque. In practice this form of control was obtained by restricting the machine to run at a nearly constant rotational speed so that, as the wind speed increased, the inclination of the air stream relative to the blade also increased, thus stalling the blades and limiting the torque produced. Since the windmill was fitted with a direct-current generator, the rotational speed was controlled by using a simple regulator to increase the excitation supplied to the generator as the power output of the machine increased.

These machines, for several were built, ran successfully under test for a period of some years but, finally, it was decided that they were still too expensive to enter the market. They had been designed to use rather low winds to enable them to benefit from a longer working period during the year. It seems likely, however, that considerably more energy could have been produced annually if they had been designed to use higher winds. The largest one, which produced a maximum output of 15 kW from a wind rotor 65 ft in diameter in a wind of 13·5 m.p.h., had three slim blades of welded sheet steel rotating at 50 r.p.m. As an additional development, this machine was the first to be connected, through a motor-generator set, to an extensive alternating-current network.

Fig. 5 The largest windmill yet built—the 1,250 kW Morgan Smith windmill for parallel operation on an alternating-current network. (United States)

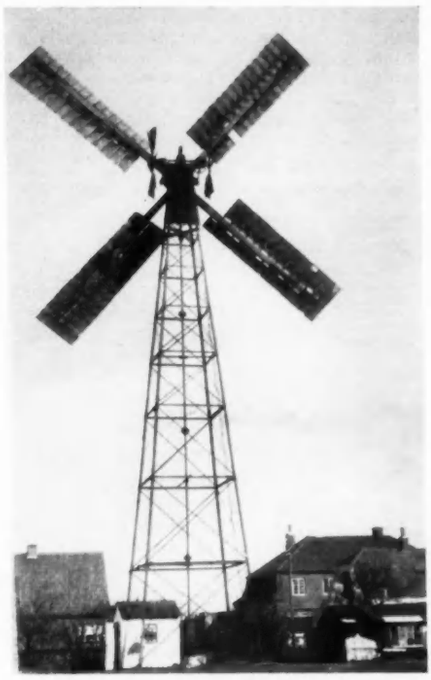

Fig. 6 35 kW direct-current Lykkegaard windmill for local supply. (Denmark)

This made possible a further reduction in the cost of the energy produced from the wind. Experience in Denmark had shown that more than half the cost of the energy supplied by the windmill and battery combination could be assigned to the battery. Also, it had been necessary to shut the windmill down when the load was light and the battery fully charged, even when useful winds were blowing, a practice which considerably reduced its possible output of energy.

When it is connected to an extensive network a windmill becomes, in effect, a negative load, reducing the demand on the main power stations and thus saving fuel. It is no longer necessary to miss opportunities to generate useful energy or to provide a storage battery. On the other hand, the windmill is now in competition with the low-cost energy from large thermal or hydro-stations. A real advantage is that the maximum power output of the windmill is not so limited to the amount of load available to it locally, but can be chosen rather on the basis of economy. A further advantage, deriving from the association of the windmill with electricity, is that the machine can be built on an exposed site, some distance away, where a larger amount of energy is available from the wind. When it became possible to combine all these advantages, consi-

Continuing The Windmill To-day

derably more energy could be produced by a wind rotor of a given size.

It was in Russia, in 1931, that a windmill was first built to feed energy directly into an a.c. network. (Fig. 4.) It had three blades, about 100 ft in diameter, driving a 100 kW induction generator through wooden gears. The tower was 100 ft high but, in addition, it was provided with an inclined strut to carry the thrust of the wind to the ground. The base of the strut was driven round a circular track by an electric motor working under the control of a wind-direction vane mounted on the head of the tower. The metal-covered blades, which were mounted upwind of the tower, could be turned about an axis parallel to their length so that, in high wind, the inclination of the wind to the blade could be reduced, thus reducing the torque produced. This movement, called "pitch-changing," is used on aircraft propellers and certain water turbines and when applied to windmills may be taken as the modern equivalent of the pivoting of the slats in the patent sail. Pitch changing was obtained by the effect of centrifugal force on offset ailerons. It is reported

Fig. 7 70 kW direct-current F. L. Smidth windmill erected in 1942 at Gedser, Denmark, for parallel operation with an alternating-current network through a motor-generator set.

that an annual output of 279,000 kWh was obtained on this site, where the annual average wind speed was 15 m.p.h., but that satisfactory control was difficult to achieve, and it can be inferred that the installation was too expensive.

The next development took place in the United States. In 1941, working to the general design of Putnam, the S. Morgan Smith company erected the largest windmill which has so far been built. (Fig. 5.) Standing on a steel lattice tower over 100 ft high, the windwheel had two variable-pitch blades, with an overall diameter of 175 ft which rotated in the lee of the tower. The head of the tower was brought into wind by an electric drive working from the signal of a wind direction vane. The electrical machine, a synchronous generator of 1,250 kW capacity, was mounted in the head and was driven by the blades through a gearbox and a hydraulic slipping coupling. In high wind the power output was limited by changing the pitch of the blades under the control of a centrifugal governor. The purpose of the hydraulic slipping coupling was to allow sufficiently large speed changes to occur at the blades to permit the centrifugal governor to operate, for the rotational speed of the generator was fixed by the network frequency. An additional feature was the hinge, provided at the root of the blades, which allowed them to lean away from the wind, while rotating, under a combination of wind thrust and centrifugal force. This motion is called "coning." With the hinge, the bending moment on the blade root is appreciably reduced.

Owing to war-time difficulties in obtaining replacements parts, this machine did not reach a satisfactory working condition until 1945, and then, shortly afterwards, the failure of one of the blades put an end to further experimental work. This failure did not detract, materially, from the technical success of the machine. On the other hand, its cost was too high by about 50 per cent, for Vermont, where very cheap hydro-power was available.

A very detailed account of the project, from its inception to the final conclusions drawn, is given in Putnam's book, "Power from the Wind," which includes an investigation into possible ways of reducing the cost of the machine. It was concluded that cost reductions could best be made by using a simpler method of power control. The use of flaps, as commonly found on aircraft wings, where they are used for controlling the lift force, was suggested. Although the design of the Darrieus machine was considered in the early stage of the project, there is no mention of its simple method of control.

Two aspects of the effects of the wind run through the ideas behind the design of this machine. One is the strong impulsive forces which may be produced by gusts, and the other is the effect of the increase in wind speed with height above ground, a phenomenon known as the wind gradient. The reasons for the adoption of the more sophisticated, and expensive, features in this design, including the coning hinge, the complex governing system and the slipping coupling, can be traced, in the main, to the interpretation of these two aspects of the wind.

Meanwhile, in Denmark, the second World War had caused a severe fuel shortage, and windmills for the generation of electricity had been brought back into service. Many were built by the Lykkegaard Company (Fig. 6) on the principles laid down by La Cour 40 years earlier, and several were installed free of charge, payment being taken on the basis of 1·10*d.* per kWh delivered.

Also, the F. L. Smidth Company had produced machines of a new design. The largest of them had three fixed-pitch narrow wooden blades sweeping a circle 80 ft in diameter and directly connected through a gearbox to a 70 kW d.c. generator mounted in the tower head, which was turned into wind by a fantail. The towers were originally of steel, but the shortage of steel made it necessary, later, to use reinforced concrete. Power control in high wind was obtained by the use of spoilers—long flat metal plates, hinged on a long side to the surface of the blade, and running parallel to its length. Normally lying flush, they could be turned by a system of rods so that they stood proud of the surface of the blade and destroyed its ability to produce a lift force. The motion of the spoilers was controlled by a centrifugal governor.

One of these machines, erected in 1942, is still in service at Gedser on the island of Falster, where it produces about 140,000 kWh annually at a cost of just over 1*d.* per kWh. (Fig. 7.) This compared favourably, in 1942, with the fuel cost of local diesel generation and was about half the cost of energy from the network, which was greatly extended at this point.

After the war, intensive studies on the application of wind power were started in several countries, including Britain, France and Germany, as well as in Denmark. In Britain, the programme of work included the construction of prototypes and two 100 kW windmills were built. Both were pilot plants intended to provide information and experience which could be applied to the construction of much larger windmills. In view of this, it was natural to draw on the very full account which was available of the large American project, and, in fact, both these machines had much in common with the Morgan Smith windmill. In particular, control of the power output in high winds was obtained by using pitch-changing blades, although the possibility of using blade stall had been considered. Eventually, this latter idea was discarded, mainly because little experience of it was available. Since these two machines have already been described in detail in this journal, it is necessary to discuss only the way in which they differed, in construction, from the American machine.

One machine was built by John Brown and Company and was erected in the Orkneys in 1950. (Fig. 8.) There were three blades which were provided with a greater degree of freedom of movement at the root by the provision of a universal joint instead of a coning hinge. In addition, the bedplate which carried the blades, mainshaft and generator, was allowed considerable freedom of movement by a complex system of springing, to avoid transmitting shock and vibration to the tower. Instead of a synchronous generator, an induction generator was used, since it was felt that the rotational speed change of this machine, with changing load, was great enough to permit the satisfactory operation of the centrifugal governor used for the control of blade pitch. In a subsequent design, based on the experience gained with this machine, many of the complexities were discarded.

The other machine, which is shown in Fig. 9 opposite, was built for Enfield Cables by de Havilland Propellers and the Redheugh Iron and Steel Company, and featured a pneumatic transmission system invented by Andreau in France. Here, the blades were hollow, with a hole at the tip, so that, in rotating, they acted as a centrifugal pump. The internal flow of air so produced was directed by ducting to the base

Fig. 8 100 kW John Brown windmill erected in 1950 at Costa Head, Orkney, for parallel operation with an alternating-current network.

of the tower, where a turbine, connected to a synchronous generator, extracted the energy from it. Although this system replaced the slipping coupling and the gearbox, it has a low efficiency, so that longer blades are required to produce a given power output.

Comprehensive testing was not possible on the site at St. Albans, where the machine was first erected in 1953, owing to the poor wind conditions there. Late in 1957 this machine

Fig. 9 100 kW Enfield windmill erected in 1953 at St. Albans, designed for parallel operation with an alternating-current network. This machine has recently been re-erected in Algeria.

was re-erected on a windy site in Algeria, where Electricité et Gaz d'Algérie intend to work it in parallel with their other generating plants. The full rated output of 100 kW was obtained shortly after erection. In Algeria the coincidence of strong winds with periods of low water storage are specially favourable to the use of wind power.

From the experience gained with these two pilot plants the possibility of building larger windmills at an economic price was not immediately apparent. Much rested on the cost reductions made possible by manufacture in quantity.

But the mechanical complexity of recent machines was seriously in question, because the assumptions on the nature of the wind and its effects on large machines, which had given rise to it, still remained to be investigated. One of these had already been questioned, as measurements made with sensitive anemometers by the Electrical Research Association had shown that the wind gradient on a windmill on a smooth tree-less hill, with good exposure, was small.

In addition, there were some encouraging developments in Denmark, where experimental work under the direction of Juul, of the South-East Zealand Electricity Supply Company (S.E.A.S.), had culminated in the construction, during the winter of 1952-53, of a windmill with a capacity of 45 kW (Fig. 10.) While this machine was of only moderate size, its simple construction showed promise of being economic and of being adaptable to bigger windmills.

The main particulars of the machine were as follows. The wind rotor, running upwind of the tower, had three blades rigidly attached to the main shaft but also supported by tie rods connecting their outer portions to a forward extension of the main shaft. Other tie rods interconnected them in the plane of rotation. As the blades were connected through a gearbox to the induction generator, they were maintained at a constant rotational speed by the frequency of the a.c. network. The power output was automatically limited by the stalling of the blades in high wind. The blades were so proportioned that the set reached synchronous speed, on no load, when the wind speed was sufficiently high to make good the losses in the drive and the generator. A centrifugal device then connected the generator to the line. In the event of a line failure, the automatic application of a brake to the main shaft and the simultaneous rotation of the rounded tips of the blades rapidly brought the machine to rest. The head was turned into wind by an electrical drive controlled by a wind-direction vane.

This promising development made it necessary to investigate the assumptions underlying earlier designs, and led to a new phase of research in Britain. Starting in 1954, the Electrical Research Association and the Chief Scientist's Division of the Ministry of Power collaborated in the work of measuring the stresses in the blades and the power output of small machines. Results showed that the changes in loading produced by irregularities in the wind were quite small and were largely masked by the effect of the forces induced in the blades each time they passed the tower. It was found that this cyclic loading could be greatly reduced by running the blades upwind of the tower, rather than downwind. It was also noticed that changes in the power output and in the non-vibratory component of the flexural stresses in the blades, connected with variations in wind speed, became progressively smaller as the blades stalled, until in high wind both were very nearly constant. Tests on machines with two blades showed that this arrangement was unfortunate, as the cyclic variations in the moment of inertia of the wind-

Fig. 10 45 kW S.E.A.S. windmill at Bogø, Denmark, for parallel operation with an alternating-current network.

wheel, about the vertical axis of yaw, gave rise to accelerations in the plane of rotation and cyclic variations in the power output. This indicated that windmills should have a minimum of three blades.

In 1957, the new machine, similar in construction to the 45 kW windmill built in 1952, was erected by S.E.A.S. at Gedser in Denmark. (Fig. 11.) In this case, however, the wind rotor was 80 ft in diameter and was coupled through a chain drive, to a 200 kW induction generator connected to the a.c. network. Measurements made by the Electrical Research Association on the stresses in the blades, in winds up to 30 m.p.h., show that, even on this larger size of windwheel, the effects of gusts and wind gradients are too small to be detected. The variations of stress which do occur, and these are quite small, can be attributed to the interference between the blades and the tower, the weight of the blades, and to the slight inclination to the horizontal given to the windshaft to allow greater clearance between the blades and the tower.

The structure of this machine is simple and very robust. The blade spars, tie rods, and the bedplate which carries the generator and main-shaft, are fabricated out of mild steel plate and standard steel sections, and the blades are

Fig. 11 200 kW S.E.A.S. windmill erected in 1957 at Gedser, Denmark, for parallel operation with an alternating-current network. This machine has a maximum output three times greater than its older neighbour, the Smidth windmill shown in Fig. 7, although both have 80 ft diameter rotors.

covered with aluminium sheet supported on timber ribs. A steel tower would be cheaper than the reinforced concrete one which has been used. Even so, the yearly output, estimated on the basis of five years running of the 45 kW machine, is likely to be 600,000 kWh at a cost of about 0·4 of a penny per kWh. This assumes, of course, that the machine will be satisfactory in service.

The 70 kW d.c. Smidth windmill, erected in 1942 and still in service, is no more than a mile from the new machine. Although both have wind rotors of the same size, the new windmill produces four times as much energy and has a maximum output three times greater than the older machine. Corn-grinding windmills with this size of wind rotor produced perhaps some 30 h.p. This is a measure of the progress achieved in 60 years, but the similarity between the structure of the power-producing components of the 200 kW windmill, and the structure of those of the later corn-grinding windmills is surprising, and is also reassuring. But this

Continuing The Windmill To-day

machine is a prototype. Further reductions in costs and improvements in performance will follow from engineering research and development.

It is possible, now that a competitive energy cost has been achieved, that the wind rotor may rejoin the water wheel as a producer of cheap energy, for it would be reasonable to suppose that this latest design could be built in larger sizes.

Several new machines, with a maximum power output in hundreds of kilowatts, are in the course of construction in France and Germany. It is to be hoped that similar developments will take place in Britain, which was, for so long, pre-eminent in this field.

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GAS-TURBINE LOCOMOTIVES

The continuous research and operating tests to which gas-turbine locomotives are being subjected in the United States is described in the annual report of the Locomotive Development Committee Bituminous Coal Research, Inc. At the end of 1957 they had accumulated 3,760 hours of operation on a coal-fired gas-turbine unit of locomotive size and 1,250 hours on a Houdry unit, in all 5,010 hours of testing. The results are said to be satisfactory and the United States coal industry doubtless have high hopes that the unit, when fully developed, will restore their supremacy as suppliers of fuel for American railroads.

The key units in the coal system—the aerated feed, the coal pump (one ran for the whole duration of the coal test, 1,110 hours, without any failure or maintenance), and the pressurised mechanical pulveriser—behaved very well. The pulveriser, on which depends to a considerable extent the efficiency of the turbine and the life of the blades, was the subject of many tests and changes in design during 1956, undertaken jointly by L.D.C. and the Riley Stoker Company. The operation of the combustors and the fly-ash separator were such that combustion efficiency was consistently over 95 per cent during the 1957 tests, and that turbine blade wear has decreased to a remarkable extent.

The report states that "economics continue favourable to the coal-fired gas-turbine." It is unfortunate that the current recession in the U.S. should have led to the whole scheme being put into cold storage. Notwithstanding this enforced marking time, the progress made in the past three years is such that the confident forecast made by leading British locomotive consultants as long as ten years ago or more, that the gas-turbine locomotive was the locomotive of the future on all non-electrified lines may well be fulfilled within a very few years.

Production

TESTING ATMOSPHERES IN ENCLOSED SPACES

*By Henry Allen**

With increasing underground work and with more operators required to enter manholes and other places where work is in progress below the earth's surface, safety techniques have kept pace and have advanced far from the days when air tests were primitive and atmospheric conditions unknown with any exactness. In fact, modern detection techniques have reached a high standard and safety is the essential factor of current methods of inspection and maintenance. The full implications of the working code, however, must be understood and certain facts appreciated, and before a permit for entry to underground workings can be issued it is necessary to know whether combustible gas is present, whether there is sufficient air to sustain respiration, and whether any toxic gases are present in dangerous concentrations.

It is accepted that normal air contains about 21 per cent of oxygen, by volume, but that a human being can manage without harm or distress when the percentage is 17, provided that there are no toxic gases present. The lowest level of oxygen at which any work can be sustained is 13 per cent. Of the contaminating agents and gases which may be in the air and constitute a hazard, carbon monoxide is the commonest; it is derived from the fermentation of organic substances, but being odour-free, it was once difficult to detect. Now its presence is quickly ascertained by means of paper waddings wetted with a dilute solution of palladium chloride which, at a sustained freezing point, can be mixed with acetone. Both are discoloured black in the presence of CO in concentrations of as little as 0·05 per cent by volume.

Three other gases likely to occur are ammonia, which has a maximum allowable concentration (or M.A.C.) for prolonged exposure of 0·01 per cent by volume; hydrogen sulphide (M.A.C. 0·002 per cent); and solvent vapours (M.A.C. 0·01 per cent). Lead acetate paper is used for detecting hydrogen sulphide, darkening on exposure to the gas. The strong and irritant odour of ammonia is usually sufficient evidence of its presence. It is also necessary to know the explosive limits of any combustible gases. When mixed with air, combustible gases become hazardous if the concentration is above the explosive limit, and hot-wire type gas detectors, which are very accurate in determining explosive limits, are now in general use. Whatever form of detector is used, it is advisable that the equipment be able to locate vapours and gases in mixture with air in a full range above a minimum of about 1 per cent. The lower explosive limits of some vapours and gases are given in Table I.

TABLE I

Gases	Lower explosive limit
	Per cent of gas in air
Hydrogen	4·0
Hydrogen sulphide	4·3
Methane	5·0–5·3
Naphthas	1·1–1·5
Iso-propyl alcohols	2·1
High-B.th.u. oil gas (having a B.th.u. per cu. ft of 1,000–1,040)	5·5–5·7

With the hot-wire type of detector for combustible gases the temperature of the surrounding air has little effect on the readings, the maximum deviation between zero deg. and 75° F being equivalent to less than 0·5 per cent of methane.

Usually, it is enough, when testing atmospheres for suitability for work, to determine whether there are toxic or combustible contaminating agents present. Sometimes, however, it may be necessary both to identify the contaminating agent and to ascertain its origin. Carbon monoxide, the contaminant that will be found most often, may indicate a breakdown of electrical insulations or the escape of exhaust gases from internal-combustion engines. A volume of above 0·5 per cent carbon monoxide, in places where there is also insufficient oxygen, may indicate the presence of fermentation gases. It ought to be a routine matter in the inspection programme that when electrical installations are inspected there should also be tests of the atmosphere—a point that is often overlooked. High-pressure regulators must also be regularly inspected. Hydrogen sulphide will occur in locations of bacteriological action, while solvent vapours will usually mean the presence of liquid.

Instruments used for testing, it goes without saying, must be maintained at the highest efficiency. Recalibration and servicing should be a routine procedure, at least once a month, but certainly on a time cycle determined by the frequency of their use.

The testing of solvent storage tanks is another problem that should perhaps be mentioned here. Various authorities, among them the Chief Inspector of Factories, in their annual reports, have stressed the danger of testing unproved vessels by means of compressed air. Only the fact that reportable accidents continue to occur as a result of the dangerous habit of subjecting to gaseous-pressure tests, vessels which have not previously undergone a suitable hydraulic test, indicates that despite the obvious foolishness of such a practice, that no one with any technical knowledge would attempt, some persons are still facing this hazard.

In the case of volatile liquids, pressures can be built up in enclosed tanks from a variety of causes, even from exposure to the sun. All solvent storage tanks should be regarded as pressure vessels and designed as such in accordance with B.S. 1500 and fitted with automatic safety pressure-release valves. When tanks, built to contain volatile liquids, have more than one compartment, each compartment should be given dished ends. In this way all the surfaces are in tension, when under pressure, and are unlikely to fail if properly constructed.

* The Yale and Towne Manufacturing Co. Ltd., Willenhall, South Staffordshire.

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The Factories Act, Certificate of Exemption, No. 13, Form 677; for steam receivers having a safe working pressure below the maximum working pressure of the boiler.

Gas Cylinders (Conveyance) Regulations. (S.R. and O., 1931, No. 679); and Compressed Gas Cylinders Regulations. (S.R. and O., 1940, No. 2009). These Orders cover vessels of seamless steel construction.

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Department of Scientific and Industrial Research, Charles House, 5-11, Regent Street, London, S.W.1.

Methods for the Detection of Toxic Gases in Industry. (No. 7.)

Research Recommendations S.12C for forged and fusion-welded containers.

British Standards Institution, 2 Park Street, London, W.1.

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Association of British Chemical Manufacturers, 86 Strand, London, W.C.2.

Gassing Casualties.

Safety Rules for Use in Chemical Works. (PART II)

Imperial Chemical Industries Limited, Imperial Chemical House, Millbank, London, S.W.1.

*I.C.I. Engineering Code B*1-4, covers the periodic examination, testing and registration of pressure vessels.

American Society of Mechanical Engineers, 29 West 39th Street, New York 18, U.S.A.

Boiler and Pressure Vessel Code.

Construction Code for Unfired Pressure Vessels for Petroleum Liquids and Gases.

American Petroleum Institute, 50 West 50th Street, New York 20, U.S.A.

Cleaning Petroleum Storage Tanks.

GYROS FOR INERTIAL NAVIGATION

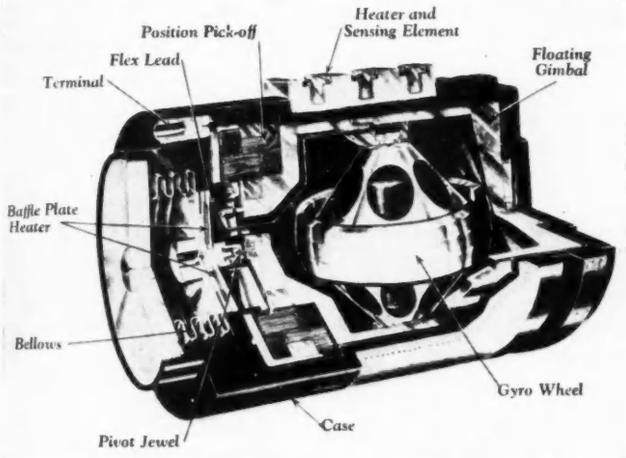
Gyroscopes of the extremely high precision required for stabilising the reference axes of an inertial navigation system are now being made by the English Electric Company Limited in their Stevenage factory under licence from the Minneapolis-Honeywell Regulator Company, Minneapolis, U.S.A. The agreement—which provides also for the exchange of information—is tripartite, the third member of the alliance being Honeywell-Brown Limited, Perivale, Middlesex, the British associate of Minneapolis-Honeywell. Marketing, both at home and overseas, will be done jointly by English Electric and Honeywell-Brown. In order to provide the necessary conditions for the manufacture of high-precision gyros, English Electric are extending their works at Luton. A large new assembly and test building under construction is designed to minimise the effect of vibrations caused by both machine tools and plant, as well as by trains which pass within ½ mile of the factory, and by the heavy traffic on the Great North Road.

It is only within the last few years that gyros sufficiently accurate for inertial guidance have been developed. We understand that Minneapolis-Honeywell are the only firm in the Western world to have solved the problems of minimising the error forces arising from bearing friction and imperfect balance, and of measuring the angle between the gimbal and the outer case with adequate precision.

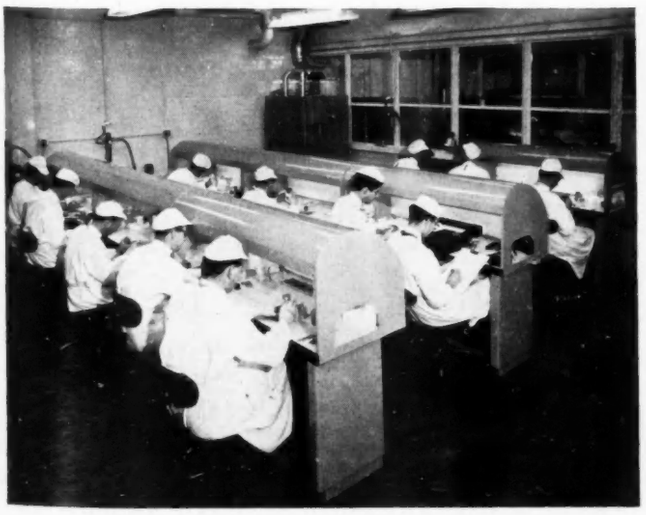
The gyroscope which the English Electric Company is to manufacture, known as the MIG, represents a very high standard of development in this art. The instrument has drift rates which can be as low as $\frac{1}{20}°$ per hour although it is smaller than a breakfast cup. The instrument is built as a single-axis device—that is, there is only one frame and pivot system around the gyro wheel, and three such gyros are necessary to stabilise a platform around three axes.

In order to overcome the frictional forces which would result were ball bearings used to support a gyro frame, the gimbal in this instrument is made as a completely sealed cylindrical canister contained within an outer one, the space between the two being filled with a special fluid. This fluid has two functions. It serves to float the inner canister at neutral buoyancy, and it provides the necessary damping to prevent the gimbal oscillating with respect to the outer casing. It is still necessary to locate the gimbal centrally relative to the outer, but this can now be accomplished by means of very small needle bearings which pivot inside sapphire jewel ring stones. Since these pivots are not supporting load, due to the flotation of the gimbal, they do not exert large disturbing forces.

The angle between the gyroscope gimbal and its outer case is measured electrically by means of rotating a laminated-iron armature inside a laminated-iron stator and coil assembly, the electrical outputs obtained being directly proportional to the angle of rotation of the gimbal system. The accuracy of the position pick offs is extremely high, of the order of 1 second of arc movement (equivalent to the angle subtended by a distance of 1 in in a radius of three miles).



Cut-away view of the MIG gyroscope; the gimbal floats in the outer casing, the needle bearings serving only to centralise it.



The " clean " area, where final assembly of inertial gyros is carried out.

Requirements of accuracy of such a standard put very high demands on the problem of manufacturing these instruments. For instance, most of the individual components have to be machined to tolerances of 0·0001 in or 0·0002 in, with surface roughness to a finish of 0·000001 in or 0·000002 in. In addition, extensive heat treatment has to be carried out in order to ensure that the dimensional stability of the material is of the highest order. To obtain the quality of assembly, so that instruments are consistently obtained from the production line that will pass the necessary tests, much engineering effort has to be put into the manufacture of tools and fixtures to eliminate human errors from difficult operations. Also, it is essential that the components should be kept completely free from contamination, since very small particles of dirt will cause a very fine pivot to stick. To this end, all assembly rooms are air-conditioned; temperature (70° F), humidity (less than 50 per cent), and dust are stricly controlled and monitored and, in addition the components are assembled inside cabinets which themselves are pressurised with filtered air.

To test the assembled gyros, it is necessary to look at extremely small rates of change of position. In more easily visualised terms, $\frac{1}{20}°$ per hour is equivalent to one complete revolution in 300 days. To measure these small rates of change of position to the accuracy required, the inherent stability of the earth's rotation is used. The earth rotates about its axis approximately once in every 24 hours, that is, about 15° an hour. If the gyroscope is aligned so that it senses only a small component of this rotation, it is possible to put step-changes of rates of rotation into the gyroscope of considerably less than $\frac{1}{20}°$ per hour; these rates of rotation can be computed very accurately by measuring the angle between the gyroscope input axis and the rotational axis of the earth.

The gyro now has to be checked to make sure that the handling it could receive in a rocket, or any other type of vehicle, does not cause it to give false readings during its life. To this end all instruments receive severe shakings on vibrators, or are subjected to high acceleration on a centrifuge to simulate the effect that sustained rocket accelerations would give. Only if the gyro has passed these tests is it considered that a satisfactory instrument has been produced which meets the high performance figures claimed by its manufacturers and designers.

SPEEDING UP PRESS TOOL DESIGN

Time can be wasted by a draughtsman drawing in, from dimensions, the outline of a standard die set on his press tool drawing. To speed up this work, Desoutter Brothers, Limited, 121 Hay Lane, Kingsbury, London, N.W.9, have produced a series of printed full size outline drawings

Time is saved, in press tool design, by tracing the outline of Desoutter standard die sets from a printed sheet supplied by the tool manufacturers.

covering the range of their most popular standardised die sets.

These can be positioned under the drawing, and used to trace the die set outline, either before the tool design has been drawn, or afterwards, to frame the tool details. In either case, time is saved. There are 13 sheets available at present, covering 30 different die sizes, and each gives, in addition to the actual outline, leading specification details of the set in tabular form, together with a list of die spaces available. A similar drawing technique was described in ENGRG., vol. 180, 1955, p. 106.

EXHIBITIONS AND CONFERENCES

This list, in chronological order, appears in the last issue of each month. Events noticed for the first time and alterations of dates, places, etc., are indicated by an asterisk (*). For details of events not included below, reference should be made to ENGINEERING, 28 March, page 406, and 25 April, page 532. Organisers are invited to send particulars of coming events to the Editor.

Mechanical Engineering Congress, Seventh International.—Mon., 2 June, to Fri., 6 June, at Scheveningen, Holland. Apply to the British Engineers' Association, 32 Victoria Street, London, S.W.1. (Tel. ABBey 2141); or to the Permanent Secretariat, International Mechanical Engineering Congress, 11 Avenue Hoche, Paris 8e.

Solid State Physics in Electronics and Telecommunications, International Conference.—Mon., 2 June, to Sat., 7 June, at The University, Brussels. Apply to the honorary general secretary, Société Belge de Physique, Loveral, Belgium.

Special Libraries Association, Annual Convention.—Tues., 3 June, to Thurs., 5 June, at the Hotel Sherman, Chicago, Ill., U.S.A. A "Brainstorming Demonstration" by the Association's Metals Division will form a part of the programme. Association's offices: 31 East Tenth Street, New York 3, U.S.A.

Gas Turbines Conference.—Wed., 4 June, to Fri., 6 June, at the hall of the Faculté Polytechnique, Boulevard Dolez, Mons. Organised by the Faculté Polytechnique de Mons, 9 Rue de Houdain, Mons, Belgium.

High Tension Networks, International Conference on.—Wed., 4 June, to Sat., 14 June, at Fondation Berthelot, 28 Rue Saint Dominique, Paris. Organised by the Conférence Internationale des Grands Réseaux Electriques (CIGRE). Apply to the secretary, British National Committee, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Tel. Leatherhead 3423.

Coil Spring Federation Research Organisation, Annual Conference.—Thurs., 5 June, to Sun., 8 June, at the Imperial Hotel, Torquay. Apply to the Federation, P.O. Box 121, 301 Glossop Road, Sheffield, 10. Tel. Sheffield 63031.

Israel Tenth Anniversary Exhibition.—Thurs., 5 June, to Thurs., 21 Aug., at the Binyaney Hacoma, Jerusalem. Organised by the Tenth Anniversary Exhibition Co., P.O.B. 6001, Jerusalem, Israel.

Canadian National Business Show.—Mon., 9 June, to Wed., 11 June, in the Automotive Building, Toronto. Show offices: 745 Mount Pleasant Road, Toronto, Canada.

Interferometry, Symposium on.—Mon., 9 June, to Wed., 11 June, at Teddington. Organised by the National Physical Laboratory, Teddington, Middlesex. Tel. Molesey 1380

Materials Handling Exposition, Eighth National.—Mon., 9 June, to Thurs., 12 June, at the Public Auditorium, Cleveland. Organised by Clapp and Poliak, Inc., 341 Madison Avenue, New York 17, U.S.A.

Automation Exposition and Congress, Fourth.—Mon., 9 June, to Fri., 13 June, in New York. Organised by Richard Rimbach Associates, Management, 845 Ridge Avenue, Pittsburg 12, Pa., U.S.A.

Technical Writers' Institute, Sixth Annual.—Mon., 9 June, to Fri., 13 June, at Rensselaer Polytechnic Institute. Apply to Mr. Jay R. Gould, Director, Rensselaer Polytechnic Institute, Troy, N.Y., U.S.A.

Study and Documentation Respecting Water: International Meetings.—Mon., 9 June, to Sat., 14 June, at Brussels and Liége, Belgium. Organised by CEBEDEAU, 2 Rue A. Stevart, Liége, Belgium.

Standardisation, 1958 Assembly of the International Organisation for.—Mon., 9 June, to Sat., 21 June, at Harrogate. Organised by the British Standards Institution, 2 Park Street, London, W.1. Tel. Mayfair 9000.

BUSINESS RECORDS

***Business Records, Second Conference on.**—Tues., 10 June, at the Connaught Rooms, Great Queen Street, London, W.C.2. Organised by Aslib, 3 Belgrave Square, London, S.W.1. Tel. BELgravia 5050.

***Human Factors in System Engineering, Conference.**—Tues. and Wed., 10 and 11 June, at Barbizon-Plaza Hotel, New York. Sponsored by Manhattan College (New York), and the Automation Exposition. Organised by Richard Rimbach Associates, Management, 845 Ridge Avenue, Pittsburg 12, Pa., U.S.A.

Vacuum Techniques, First International Congress on.—Tues., 10 June, to Fri., 13 June, at Namur, Belgium. Apply to the secretariat, CSN/ERM, 30 Avenue da la Renaissance, Brussels 4.

Building Plant Exhibition, 12th.—Wed., 11 June, to Wed., 18 June, at Pebble Mill Road, Edgbaston, Birmingham. Organised under the auspices of the Ministry of Works, Lambeth Bridge House, London, S.E.1. Tel. RELiance 7611, ext. 1177.

***Plant Layout for Automation, Conference.**—Thurs. and Fri., 12 and 13 June, at Barbizon-Plaza Hotel, New York. Sponsored by the Plant Layout Technical Workshop, Oakmont, Pa., and the Automation Exposition. Organised by Richard Rimbach Associates, Management, 845 Ridge Avenue, Pittsburg 12, Pa., U.S.A.

Cargo Handling Week, Second International.—Sat., 14 June, to Tues., 24 June, at Antwerp. Offices: 1A Korte Clarenstraat, Antwerp, Belgium.

***Hydraulics Conference, Seventh.**—Mon., 16 June, to Wed., 18 June, at the State University of Iowa. Organised by the Iowa Institute of Hydraulic Research, State University of Iowa, Iowa City, U.S.A.

Electricity: Collective Economical Enterprises in the Public Section of the Industry, International Congress.—Mon., 16 June, to Fri., 20 June, in Liége. Organised by the Association Liégeoise d'Electricité, 30 Rue des Augustins, Liége, Belgium.

***British Electrical Power Convention.**—Mon., 16 June, to Fri., 20 June, at Brighton. Theme: "Electricity and World Progress—Britain's Contribution." Organised by the British Electrical Power Convention, 26-27 Cockspur Street, London, S.W.1. (Tel. WHItehall 1928.) An exhibition of electrical apparatus will be held in Brighton during the same period. Organisers: The British Electrical Development Association, 2 Savoy Hill, London, W.C.2. Tel. TEMple Bar 9434. (Change of address of the BEPC.)

Electronics and Nuclear Energy, Fifth International Congress and Exhibition.—Mon., 16 June, to Mon., 30 June, at Rome. Organised by the Rassegna Internazionale Electtronica e Nucleare, 14 Via delia Scrofa, Rome. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard Street, London, W.1. Tel. GERrard 4951.

Chemical and Petroleum Engineering Exhibition.—Wed., 18 June, to Sat., 28 June, at Olympia, London, W.14. Sponsored by the British Chemical Plant Manufacturers' Association and the Council of British Manufacturers of Petroleum Equipment. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar Square, London, W.C.2. Tel. WHItehall 0568.

Iron and Steel Institute Special Meeting in Belgium and Luxembourg.—Wed., 18 June, to Sat., 28 June, at Brussels, Charleroi, Liége and Luxembourg. Organised by the Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1. Tel. SLOane 0061.

CIVIL ENGINEERING

Civil Engineering Problems Overseas, Conference on.—Week commencing Mon., 23 June, at the Institution of Civil Engineers, Great George Street, London, S.W.1. Open, in certain cases, to non-members. Apply to the secretary of the Institution, at the above address. Tel. WHItehall 4577.

***Coal Preparation Congress, Third International.**—Mon., 23 June, to Sat., 28 June, in Brussels and Liége. Organised by the Institut National de l'Industrie Charbonnière, 7 Boulevard Frére Orban, Liége, Belgium.

Organisation of Chemical Engineering Projects, Symposium.—Tues., 24 June, to Thurs., 26 June, at Olympia, London, W.14. Organised by the Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. Tel. BELgravia 3647.

***Royal Meteorological Society Meeting.**—Wed., 25 June, to Fri., 27 June, in the Museum Building, Trinity College, Dublin. Apply to the Society, 49 Cromwell Road, South Kensington, London, S.W.7. Tel. KENsington 0730.

Welding, International Institute of, Annual Assembly.—Wed., 25 June, to Tues., 1 July, in Brussels. Offices of the Institute: 54 Princes Gate, Exhibition Road, London, S.W.7. Tel. LANgham 7488.

Office Machine Dealers' Association, National Exhibition.—Sun., 29 June, to Wed., 2 July, at the Schroeder Hotel, Milwaukee. Association offices: 1542 Hillhurst Avenue, Los Angeles 27, Cal., U.S.A.

Institution of Naval Architects, Summer Meeting in Paris.—Mon., 30 June, to Fri., 4 July. Organised by the Institution of Naval Architects, 10 Upper Belgrave Street, London, S.W.1. Tel. SLOane 4622.

High Energy Nuclear Physics, Second CERN Conference.—Mon., 30 June, to Sat., 5 July, at Geneva. Organised by the European Organisation for Nuclear Research (CERN), Geneva 23, Switzerland.

Royal Institution of Chartered Surveyors, Annual Conference.—Tues., 1 July, to Sat., 5 July, at The University, Exeter. Theme: "The Development of Land as an Investment for the Future." Offices of the Institution: 12 Great George Street, London, S.W.1. Tel. WHItehall 5322.

***Physical Society, Optical Group Summer Meeting.**—Fri., and Sat., 4 and 5 July, at the Department of Glass Technology of Sheffield University, Elmfield, Northumberland Road, Sheffield 10. Organised by Dr. W. T. Welford, Technical Optics Section, Imperial College, London, S.W.7. Offices of the Society: 1 Lowther Gardens, London, S.W.7. Tel. KENsington 0048.

***Electronics Exhibition and Convention, 13th Annual.**—Thurs., 10 July, to Sat., 12 July, and Mon., 14 July, to Wed., 16 July, at the Manchester College of Science and Technology. Organised by the Northern Division of the Institution of Electronics. Apply to the hon. secretary of the Institution: Mr. W. Birtwistle, 78 Shaw Road, Rochdale, Lancs. Tel. Rochdale 48759.

***Industrial Co-Partnership Association, 28th Summer Conference.**—Fri., 11 July, to Sun., 13 July, at Girton College, Cambridge. Theme: "The Mainsprings of Industrial Goodwill." Offices: 36 Victoria Street, London, S.W.1. Tel. ABBey 3342.

Steric Effects in Conjugated Systems, Symposium.—Tues., 15 July, to Thurs., 17 July, at Hull. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

High Polymers, International Conference.—Mon., 21 July, to Thurs., 24 July, at The University, Nottingham. Organised by the Conference Secretariat, Department of Scientific and Industrial Research, 5-11 Regent Street, London, S.W.1. Tel. WHItehall 9788.

Mathematicians, International Congress of.—Thurs., 14 Aug., to Thurs., 21 Aug., in Edinburgh. Offices: 16 Chambers Street, Edinburgh 1.

Australian and New Zealand Association for the Advancement of Science, 33rd Congress.—Wed., 20 Aug., to Wed., 27 Aug., at Adelaide. Apply to Dr. R. S. Burdon, Department of Physics, University of Adelaide, Adelaide, South Australia.

***Mathematical Statistics Conference.**—Fri., 22 Aug., to Mon., 25 Aug., at The University, St. Andrews. Organised by the Royal Statistical Society, 21 Bentinck Street, London, W.1. Tel. WELbeck 7638.

BRITISH ASSOCIATION

British Association Meeting.—Wed., 27 Aug., to Wed., 3 Sept., in Glasgow. Apply to the secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. Tel. REGent 4677.

Combustion, Seventh International Symposium on.—Thurs., 28 Aug., to Wed., 3 Sept., at Oxford University, and the Royal Institution, Albemarle Street, London, W.1. Organised by the Combustion Institute, 936A Union Trust Building, Pittsburg 19, Pa., U.S.A. Communications to The Combustion Institute Committee, c/o The Institute of Fuel, 18 Devonshire Street, London, W.1. Tel.: LANgham 7124.

***Salinity Problems in Arid Zones, Symposium.**—In September, at The University, Teheran, Iran. Organised jointly by UNESCO and the Iranian Government. Apply to the Natural Sciences Department, UNESCO, 19 Avenue Kléber, Paris 16e.

Peaceful Uses of Atomic Energy, Second International Conference.—Mon., 1 Sept., to Sat., 13 Sept., at Geneva. Secretariat: 1 Place du Lac, Geneva, Switzerland. Apply to the secretary, the executive committee, 1958 Geneva Conference, Atomic Energy Research Establishment, Harwell, Berks. See ENGINEERING, 16 August, 1957, page 218.

Pan American Federation of Engineering Societies, 5th Convention.—Tues., 2 Sept., to Sat., 6 Sept., at Montreal, Canada. Organised by the Engineers Joint Council, 29 West 39th Street, New York 18.

CYBERNETICS

Cybernetics, Second International Conference on.—Wed., 3 Sept., to Wed., 10 Sept., at Namur. Organised by the International Association for Cybernetics, 13 Rue Basse-Marcelle, Namur, Belgium.

***Cologne Fair (Household Goods and Hardware).**—Fri., 5 Sept., to Mon., 8 Sept., in Cologne. *Agent:* Mr. M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

American Chemical Society.—Sun., 7 Sept., to Fri., 12 Sept., at Chicago, Ill., U.S.A. Organised by the Society, 1155 Sixteenth Street, Washington 6, D.C., U.S.A.

Coal Petrology, First International Meeting on.—Wed., 10 Sept., to Sat., 13 Sept., at Heerlen, Holland. Organised by the Committee on Coal Petrology, Geoligsch Bureau, Akerstraat 86-88, Heerlen, Holland.

***International Scientific Film Association; 13th Congress.**—Wed., 10 Sept., to Sat., 20 Sept., in Moscow. Apply to the Scientific Film Association, 164 Shaftesbury Avenue, London, W.C.2. Tel. TEMple Bar 4694.

***Shipping and Commercial Fishing Exhibition**—Thurs., 11 Sept., to Wed., 17 Sept., in Hull. Organised by Anglo-European Exhibitions Ltd., 45 Park Lane, London, W.1.

Conservation of Nature and Natural Resources, International Union for.—Thurs., 11 Sept., to Fri., 19 Sept., at Athens and Delphi, Greece. Sixth general assembly and seventh technical meeting. Union address: 31 Rue Vautier, Brussels, Belgium.

***Kekulé Symposium on Theoretical Organic Chemistry.**—Mon., 15 Sept., to Wed., 17 Sept., in London. Arranged by the Chemical Society under the auspices of the Section of Organic Chemistry of the International Union of Pure and Applied Chemistry. Offices of the Society: Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

Large Dams, International Commission on, World Power Conference.—Mon., 15 Sept., to Sat., 20 Sept., in New York. Communications to the secretary, British National Committee on Large Dams, 201-202 Grand Buildings, Trafalgar Square, London, W.C.2. Tel. WHItehall 3966.

Gas Congress, Seventh International.—Mon., 22 Sept., to Thurs., 25 Sept., in Rome. Organised by the International Gas Union, 4 Avenue Palmerston, Brussels 4, Belgium.

***Institute of Metals Autumn Meeting.**—Mon., 22 Sept., to Sat., 27 Sept., in Birmingham. Offices of the Institute: 17 Belgrave Square, Westminster, London, S.W.1. Tel. BELgravia 3291.

***Future of Non-Ferrous Mining in Great Britain and Ireland, Symposium.**—Tues. and Wed., 23 and 24 Sept., at 21 Tothill Street, London, S.W.1. Organised by the Institution of Mining and Metallurgy, 44 Portland Place, London, W.1. Tel. LANgham 3802.

***Gearing, International Conference.**—Tues., 23 Sept., to Thurs., 25 Sept., in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476. (Dates finally settled.)

***"Photokina" International Photographic and Cinematographic Exhibition.**—Sat., 27 Sept., to Sun., 5 Oct., in Cologne. *Agent:* Mr. M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

***Civil Engineering in Agriculture, Fifth Congress.**—Mon., 29 Sept., to Sat., 4 Oct., in Brussels. Apply to the Agricultural Attaché, Belgian Embassy, 105 Eaton Square, London, S.W.1.

***Chemical Engineering Exhibition ("KJEMI-TEKNIKK 58").**—In October at Oslo. Organised by the Studieselskapet for Norsk Industri, Forskningsveien 1, Blindern/Oslo, Norway.

***Recent Developments in Precast Concrete, Symposium.**—Tues., 7 Oct., at the Building Centre, 26 Store Street, London, W.C.1. Apply to Concrete Ltd., 16 Northumberland Avenue, London, W.C.2. Tel. WHItehall 5504.

***International Road Federation, Third World Meeting.**—Sun., 26 Oct., to Fri., 31 Oct., in Mexico City. Offices of the Federation: Abbey House, Victoria Street, London, S.W.1. Tel. ABBey 6177.

Automatic Merchandising Convention and Exhibition, National.—Sun., 2 Nov., to Wed., 5 Nov., at Kiel Auditorium, St. Louis. Offices: 7 S. Dearborn Street, Chicago, Ill., U.S.A.

SCIENTIFIC INSTRUMENTS

Scientific Instrument Manufacturers' Association of Great Britain (SIMA), Convention.—Thurs., 6 Nov., to Sun., 9 Nov., at the Majestic Hotel, Harrogate. Association's offices: 20 Queen Anne Street, London, W.1. Tel. LANgham 4251.

Cycle and Motor Cycle Show.—Sat., 15 Nov., to Sat., 22 Nov., at Earl's Court, London, S.W.5. Organised by the British Cycle and Motor Cycle Industries Association, Ltd., The Towers, Warwick Road, Coventry. Tel. Coventry 62511.

Electronic Computer Symposium and Exhibition.—Fri., 28 Nov., to Thurs., 4 Dec., at Olympia, London, W.14. Apply to Radio Communication and Electronic Engineering Association, 11 Green Street, London, W.1. Tel. MAYfair 7874.

***National Power Show (Exposition of Power and Mechanical Engineering).**—Mon., 1 Dec., to Fri., 5 Dec., in New York. Organised by the International Exposition Co., 480 Lexington Avenue, New York 17.

Smithfield Show and Agricultural Machinery Exhibition.—Mon., 8 Dec., to Fri., 12 Dec., at Earl's Court, London, S.W.5. Apply to the exhibition manager, Smithfield Show Joint Committee, 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

***Reliability and Quality Control in Electronics, Fifth National Symposium.**—Mon., 12 Jan., to Wed., 14 Jan., 1959, at the Bellevue-Stratford Hotel, Philadelphia, Pa., U.S.A. Apply to Mr. R. Brewer, Research Laboratories, General Electric Co., Ltd., Wembley, Middlesex. Tel. Arnold 1262.

***World Fishing Boat Congress, Second.**—Sun., 5 April, to Fri., 10 April, 1959, at the headquarters of the Food and Agriculture Organisation of the United Nations (FAO), Rome. Apply to that organisation.

Co-ordination Chemistry, International Conference on.—Mon., 6 April, to Sat., 11 April, 1959, in London. Sponsored by the International Union of Pure and Applied Chemistry. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

Engineering Exhibition (22nd Engineering, Marine, Welding and Nuclear Engineering Exhibition).—Thurs., 16 April, to Thurs., 30 April, 1959, at Olympia, London, W.14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar Square, London, W.C.2. Tel. WHItehall 0568.

***National Industrial Production Show of Canada.**—Mon., 4 May, to Fri., 8 May, 1959, in the Exhibition Park, Toronto. Sponsored by the Canadian Welding Society, the Canadian Council of Foremen's Clubs, and the American Society of Mechanical Engineers (Ontario Section). *Managers:* E. M. Wilcox Ltd., 19 Melinda Street, Toronto, Canada.

***Instrumentation and Computation in Process Development and Plant Design, Symposium.**—11-13 May, 1959, in London. Organised by the Institution of Chemical Engineers, the Society of Instrument Technology and the British Computer Society. Address of the Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. Tel. BELgravia 3647.

***National Education and Careers Exhibition.**—Mon., 25 May, to Thurs., 4 June, 1959, at Olympia, London, W.14. Organised by the National Union of Teachers. Exhibition offices: Hamilton House, Mabledon Place, London, W.C.1. Tel. EUSton 2442.

Research and Development

DYNAMIC CALIBRATION OF FATIGUE-TESTING MACHINES

By T. M. Dowell, B.SC., A.R.T.C.*

Summary.—*The article describes a tried and tested method of calibrating direct-stress fatigue-testing machines using an electrical resistance strain-gauge technique. Discussion of the theory, both of the straightforward load calibration and the determination of axiality of loading, is included.*

The load applied by a direct-stress fatigue-testing machine is usually adjusted to the required value by reference to a dynamometer through which the load is transmitted to the test specimen. In some such machines the dynamometer can be calibrated under static loads by means of a proving ring and the assumption may be made that the results are valid for dynamic loads. For some machines operating at low frequencies this does not lead to serious error, but inaccuracies in load setting increase to appreciable values as test frequencies are raised. It is generally desirable, and often essential, to have some means of calibrating the machines under dynamic load conditions. In addition, it is of importance in fatigue tests generally, and particularly for determinations using notched test specimens, to know that the applied load is truly axial. The present article, written as a result of numerous requests for information on the calibration of fatigue-testing machines, describes a well established method[1] using a strain-gauge weighbar technique which has been in use for several years at the Mechanical Engineering Research Laboratory of the Department of Scientific and Industrial Research at East Kilbride. In view of the fact that fatigue-testing machines require to be calibrated at fairly frequent intervals the laboratory apparatus has recently been redesigned and now consists of readily portable units which are easily interconnected and simple to operate.

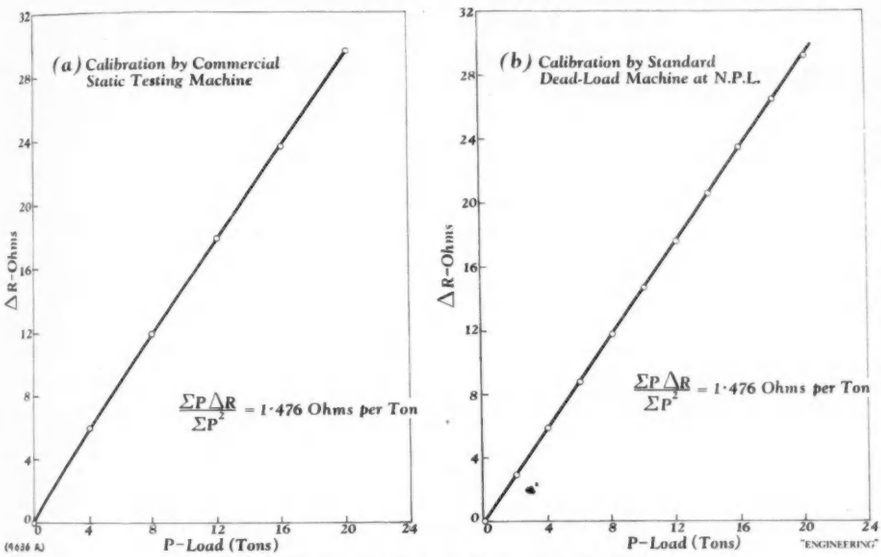

(a) Calibration by Commercial Static Testing Machine
(b) Calibration by Standard Dead-Load Machine at N.P.L.
ΔR-Ohms
P-Load (Tons)
ΣPΔR / ΣP² = 1·476 Ohms per Ton
(4636 A)
"ENGINEERING"

Fig. 1 Static calibration of dynamic weighbar.

LOAD MEASUREMENTS BY STRAIN-GAUGE WEIGHBAR

The measurement of load by means of a strain-gauge weighbar is basically a matter of resistance measurement; of the many available methods for the measurement of medium resistances the best, and commonest, is the Wheatstone bridge. By fitting the weighbar in a fatigue-testing machine and measuring the total peak-to-peak resistance change under dynamic loading, the total peak-to-peak load range can be determined. If the weighbar be calibrated previously in a static loading machine then the load can be directly related to the change in resistance of the gauge without resort to the gauge factor. Such a procedure is desirable for the most accurate work since the gauge factor, obtained by the manufacturers from batch sampling, may vary from gauge to gauge.

The static calibration of the weighbar may be performed by means of a bridge consisting of a strain-gauge arm, a balancing arm and ratio arms containing equal resistors. The bridge is energised from a direct-current supply and the output taken to a sensitive galvanometer. The calibration is effected by applying known, incremental loads to the weighbar, balancing the bridge, and noting the changes in resistance. Fig. 1 (*a*) shows the result of such a calibration performed by means of a commercial static testing machine. As no temperature compensation was employed, the resistance changes were obtained from the mean of two consecutive readings at each load with a zero reading between each. These results are compared in Fig. 1 (*b*) with the calibration of the same weighbar in the 50-ton standard deadweight machine at the National Physical Laboratory, where the calibration was performed in the temperature- and humidity-controlled cabinet in which the standard is housed. It is interesting to note that for these particular calibrations the factors obtained by using the method of least squares were identical.

PRINCIPLE OF DYNAMIC CALIBRATION

With the statically calibrated weighbar inserted in the fatigue-testing machine and an unknown alternating load applied it will now be possible to determine the load magnitude provided the resistance change can be determined. Since the total resistance of the gauge arm is continuously varying about its mean value there can be no question of balancing the bridge in the manner described for the static calibration of the weighbar. It would, however, be possible to measure the peak-to-peak value of the bridge output voltage and obtain the total resistance change by calculation. Alternatively, the resistance change under dynamic loading could be obtained by comparison with the voltage change obtained when a known resistance change was brought about in the gauge arm. The accuracy of these methods would, however, depend on the stability of the bridge voltage supply and the gain of any electronic amplifiers to which the output may be connected. An extremely simple null method, independent of bridge supply voltage and amplifier gain, is indicated in Fig. 2.

In this case the bridge is energised from a direct-current supply and the output is taken through a short-circuiting vibrator and electronic amplifier to a cathode-ray oscilloscope. If the short-circuiting vibrator were omitted the trace on the oscilloscope would simply be a reproduction of the load cycle as shown in Fig. 3 (*a*). The purpose of the short-circuiting vibrator is to produce on the oscilloscope a reference line which corresponds to the bridge balanced condition. This condition, no output from the bridge, is indistinguishable from a short circuit across the amplifier input since under both conditions the points *x* and *y* (Fig. 2) are at the same potential. The waveform produced at the input to the osilloscope when the amplifier input is intermittently short circuited is as shown in Fig. 3 (*b*). By adjustment of the oscilloscope time base a trace as shown in Fig. 3 (*c*) is obtained. Here the trace of the load cycle of the fatigue-testing machine is superimposed on a horizontal line which, while being independent of the bridge output, is nevertheless the trace which would be obtained if the bridge were balanced. At the instants when the alternating trace coincides with the reference line the bridge is in fact balanced. Adjustment of the variable resistor in the bridge circuit will have the effect of altering the direct current level of the bridge output and will therefore move vertically the alternating trace on the oscilloscope. The reference line, being independent of the bridge output will, of course, remain unaltered. It is therefore possible, by adjustment of the calibrated resistor, to balance first one peak and then the other against the reference line as shown in Figs. 3 (*d*) and (*e*). The difference between these two resistance readings gives the peak-to-peak resistance change of the strain-gauge arm and therefore the load range.

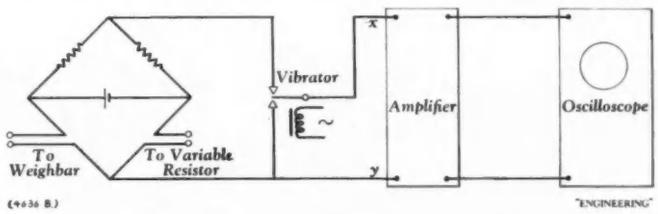


Fig. 2 Diagram of apparatus for calibration of fatigue machines.

As the bridge is balanced at the instant when

* Mechanical Engineering Research Laboratory, East Kilbride, Glasgow.

Continuing Research and Development

the peak of the trace is coincident with the reference line the measurement is, in fact, a null method. The balance is independent of the bridge voltage supply or the amplifier gain. This can be easily verified by varying the gain of the amplifier. The only effect is to alter the sensitivity of measurement. Fig. 3(*f*) shows how the bridge balance may be performed at increased sensitivity by increasing the oscilloscope gain.

BRIDGE SENSITIVITY

It can be shown that under conditions of optimum bridge sensitivity a small change, ΔR, in the gauge resistance, R, produces a change in the bridge output $\Delta Vo = \frac{V}{4}\frac{\Delta R}{R}$, where V = bridge supply voltage, provided no current is taken by the output. In practice, the change of resistance, ΔR, is small and since the bridge output is taken to an electronic amplifier of high input impedance the current drawn from the bridge is negligible.

But $\frac{\Delta R}{R} = K\frac{\Delta L}{L}$, where K = gauge factor, therefore, $\Delta Vo = \frac{V}{4} K \frac{\Delta L}{L}$. Thus the sensitivity is proportional to the bridge supply voltage, the gauge factor, and the strain produced by a given load. Theoretically, the sensitivity is independent of the gauge resistance but, due to the fact that the gauges have a given current rating, the maximum permissible bridge supply voltage is proportional to the gauge resistance. Therefore, for maximum sensitivity high resistance gauges should be employed with a large bridge voltage, the gauge factor should be large, and the cross-sectional area of the weighbar as small as possible consistent with the stresses being well below the point where any hysteresis effects occur.[2]

It has been found convenient to mount four gauges of approximately 2,500 ohms each on the weighbar, series connect them in one arm of the bridge, and use a bridge supply voltage of 90 to 180 volts depending on the permissible gauge current. The gauges are affixed axially with one on each face of a rectangular bar or at 90° spacing round a circular bar. Since the resistance of the gauge arm of the bridge is approximately 10,000 ohms the calibrated balancing arm can conveniently be a conventional five-dial decade box variable in steps of 1,000 ohms to 0·1 ohm. For even higher accuracy a slide wire can be used to resolve the resistance readings still further.

DESCRIPTION OF CIRCUIT

Fig. 4 shows the circuit diagram for the bridge unit when used in conjunction with a high gain oscilloscope. The short-circuiting vibrator employed is a commercially available d.c./a.c. converter selected for its low noise and pick-up. The pre-amplifier consists of a low-hum, low-microphony pentode connected as a triode to secure low noise operation. Further to reduce pick-up the valve heater supply is balanced with respect to earth by means of a 100 ohm potentiometer with the centre tap earthed. The amplifier output is taken to a cathode-ray oscilloscope of sufficient band-width to avoid distortion of the reference pulses from the vibrator. The bridge output may be switched directly to a galvanometer connecting point for the purpose of statically calibrating the weighbar. A neon tube is used to indicate when the bridge is energised. This tube has a low current consumption (0·3 mA) and has the added advantage that it will not strike when the battery voltage has fallen to about 75 volts. The anode supply for the pre-amplifier must be taken from a stabilised power supply of low ripple content. Fig. 5 shows such a supply with series stabiliser valve and cascade shunt amplifier.[3] The bridge unit, pre-amplifier and stabilised power supply are housed in a steel instrument case, using a standard 19 in front panel which is suitable for standard rack mounting if desired. The power supply is screened and kept well away from the bridge components, while the bridge supply is taken from a dry battery housed in a screened compartment. The remainder of the apparatus consists of a portable oscilloscope, a decade resistance box, and a series of strain-gauge weighbars designed for various load capacities.

ACCURACY OF MEASUREMENT

The apparatus described has been designed for use as a standard of dynamic load measurement. In performing the static calibration of the weighbar the bridge contained in the dynamic measuring apparatus is used in conjunction with the same decade resistor as is used in the dynamic calibration. Hence, by calibrating the weighbar against the National Physical Laboratory standard, an absolute calibration is achieved. No temperature compensation is necessary for dynamic strain measurements as the effect of temperature is to alter the mean resistance of the gauges and to leave unaltered the periodic resistance change due to the dynamic strain. The major source of inaccuracy is the difference in the resolution of the resistance readings in the static calibration of the weighbar and its subsequent dynamic use. In the static calibration the resistance readings can be resolved to within 0·01 ohm in 10,000 ohms, whereas in the dynamic calibration it is difficult to resolve the reading to better than 0·05 ohm. For the example previously given, a weighbar designed for use in a machine of 20 tons capacity, the calibration factor was approximately 1·5 ohms

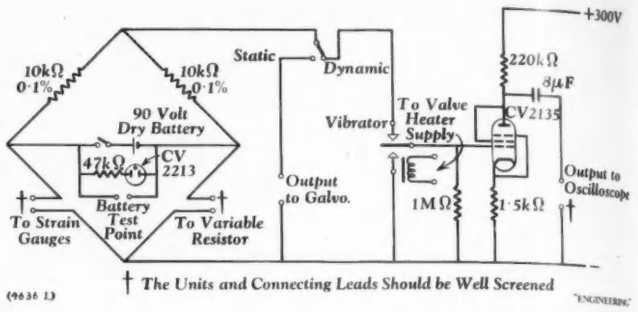
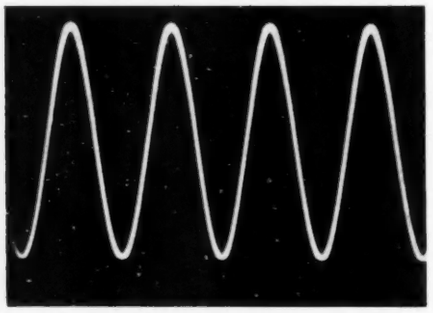


Fig. 4 Bridge, vibrator and pre-amplifier.

Fig. 3 Waveforms in the calibration apparatus.



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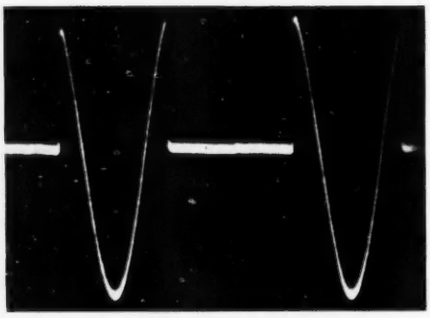

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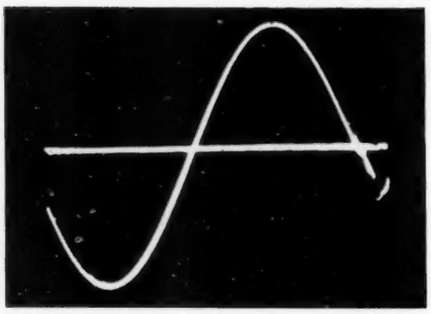

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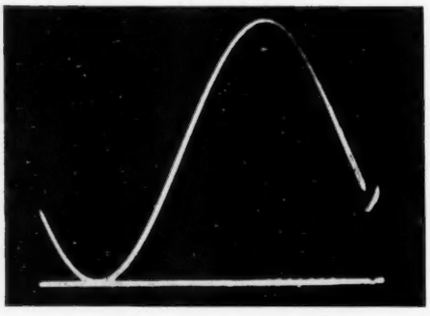

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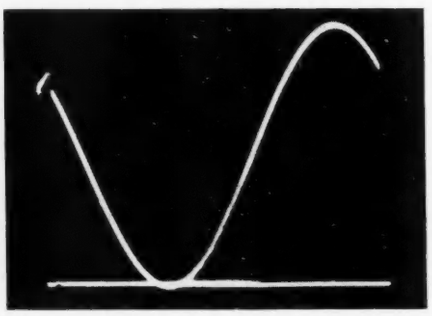

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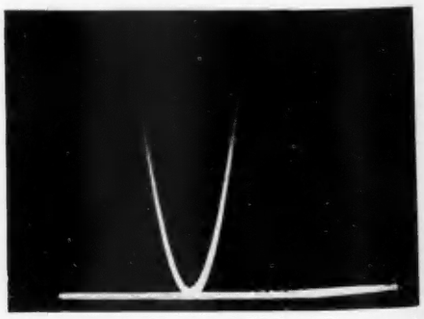


f

per ton (Fig. 1). For a dynamic calibration in which the resistance readings are resolved to only 0·1 ohm, the possible deviations at given loads are as shown in Table I.

In performing a calibration, a range of loads is taken and a line drawn through the points obtained. In this way the possible inaccuracies at given loads are minimised. By this means it should be possible to achieve an overall accuracy of better than 1 per cent in the calibration of fatigue-testing machines. In many cases the sensitivity of the apparatus is greater than that of the dynamometer by which the load is measured. Fig. 6 shows the result of a calibration carried out on a 20 ton Schenck fatigue machine. The machine together with the calibration apparatus, is shown in Fig. 7.

TABLE I.—*Possible Deviation at Various Loads*

Load (tons)	Deviation (per cent.)
5	1·3
10	0·66
15	0·44
20	0·33

The axiality of loading of the fatigue machine is easily checked by mounting a mechanical extensometer on each of the four sides of the weighbar in turn (or at 90° intervals on a circular bar), and applying a series of static loads. The same information is obtained by using a single-resistance strain gauge and taking readings over a range of static or dynamic loads and repeating the process with the bar rotated to various positions. Fig. 8 shows the results of a dynamic test on the 20-ton Schenck machine using the standard weighbar and apparatus already described. A single gauge on the weighbar was connected into the bridge circuit and readings were taken with the gauge in each of the four positions shown in the inset on Fig. 8. This shows quite clearly that bending was taking place in a plane parallel to the faces B and D and that re-alignment was necessary.

If resistance strain gauges affixed to opposite faces of a bar are connected in adjacent arms of a Wheatsone bridge then it can be shown (see Appendix) that the bridge output depends only on the bending present and is quite independent of the axial load. Since the bending stress, f, due to a bending moment M, is given by $f = M\frac{Y}{I}$ where Y = distance from neutral axis and I = second moment of area of the section, then the ratio $\frac{Y}{I}$ should be a maximum for maximum sensitivity in the detection of bending stresses. This means, of course, that a simple weighbar designed for maximum sensitivity to direct loads is not particularly suited to the determination of the axiality of these loads. If the principle outlined in the Appendix be employed then it is desirable to use a test piece designed for a large strain sensitivity in bending.

CONCLUSIONS

The principle described has been in use at the Mechanical Engineering Research Laboratory for several years and has proved satisfactory on the fatigue machines installed there. The frequency range of these machines is 30 to 300 cycles per sec. Initially the short-circuiting vibrator consisted of contacts mounted on the fatigue machines but the present arrangement has proved much more convenient and does away with the need for the design of contact sets for each individual testing machine. The author's attention has recently been drawn to a system using the same underlying principle but employing a vibrator driven electronically at the same frequency as the fatigue-testing

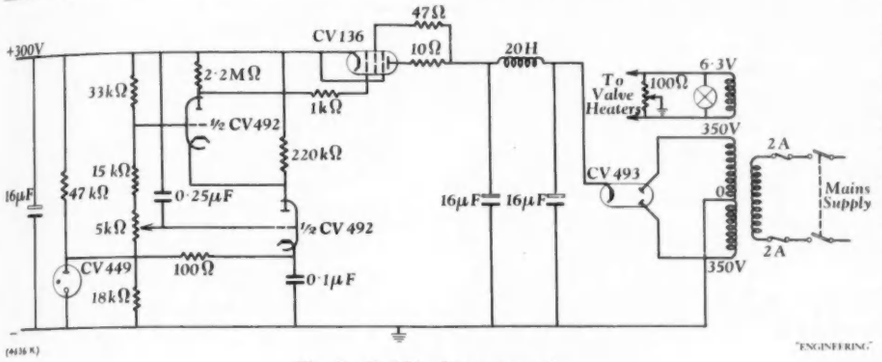


Fig. 5 Stabilised power supply.

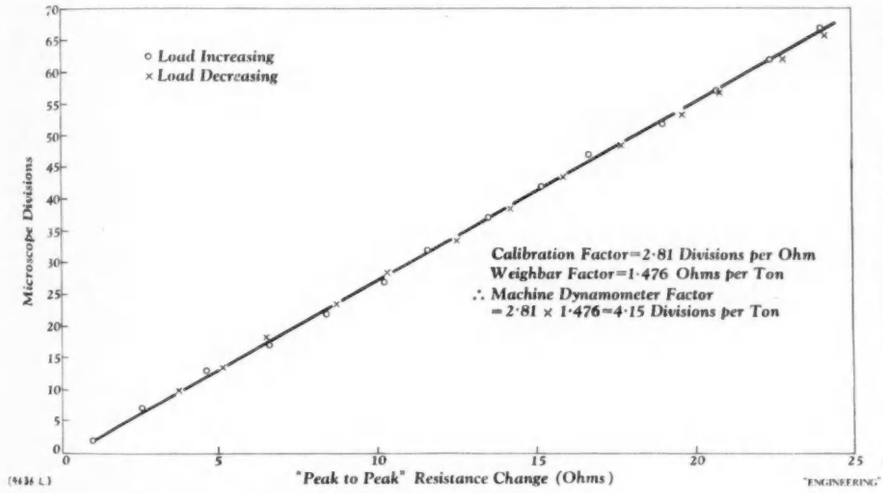


Fig. 6 (above) Dynamic calibration of 20 ton Schenck fatigue machine.

Fig. 7 (below) Schenck machine with calibration apparatus.

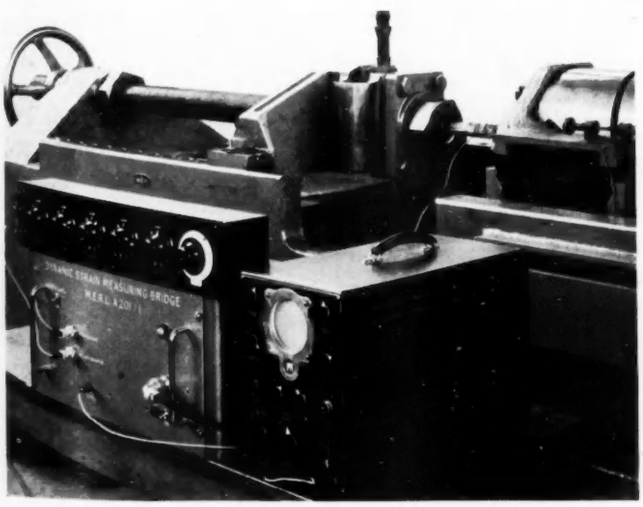
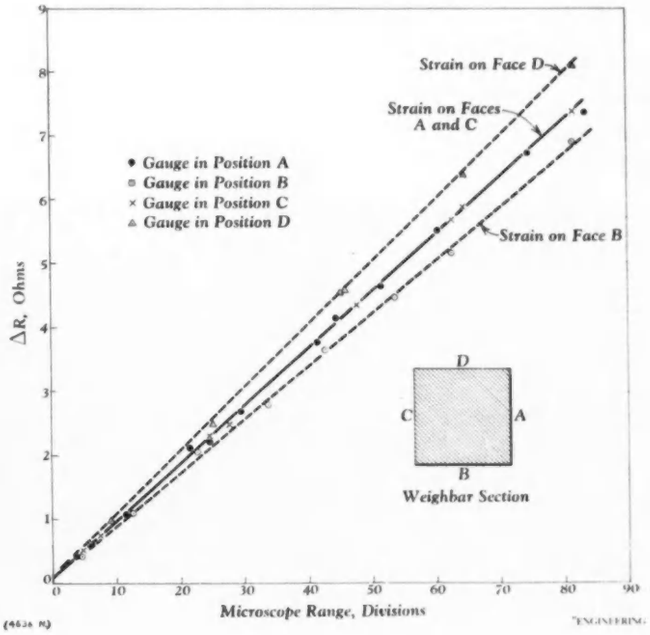


Fig. 8 (below) Check of axiality of loading on Schenck machine.



Continuing **Research and Development**

AMPLIFICATION IN AN ELECTROLYTE

Transistor action at a semiconductor-electrolyte interface modulated by an an electrical field is described by J. F. Dewald in a paper presented to the American Physical Society in Chicago.

Fig. 1 Gains in excess of 15 dB have been achieved in a semiconductor device that operates in an electrolyte.

The author is at Bell Telephone Laboratories. Recent laboratory experiments have demonstrated amplifier operation at 1 kc/s with gain in excess of 15 dB.

Initial work on conductivity modulation at a semi conductor-electrolyte interface was carried out more than ten years ago by W. H. Brattain and John Bardeen, at Bell Telephone Laboratories, during their early studies of transistor action. During their experiments, they discovered minority carrier injection at small-area contacts, which led ultimately to the first point-contact transistor. The electrolyte field-effect employed in the present work was all but forgotten in the ensuing rapid developments in transistor science and technology.

The experimental device described by Mr. Dewald uses a hexagonal rod-like crystal of very pure zinc oxide as the semiconductor, immersed in a highly conducting electrolyte. A diagram of the device is shown in Fig. 2. A platinum electrode placed near the rod serves as the grid element. Because zinc oxide is a large-energy-gap semiconductor, it can be operated in a high enrichment condition, with one end of the crystal cathodically biased with respect to the solution, and the other end anodically biased. Somewhere between the ends is a neutral point which is unbiased, where the energy bands are flat right up to the surface of the crystal. As this neutral point shifts back and forth (Fig. 3) under the influence of varying biasing grid voltages, the resistance of the crystal changes, passing a current which follows the driving frequency very closely. A fairly extended range of linear response is obtained.

To make electrical contact to the zinc oxide crystal, the two ends are first indium plated to assure good ohmic contact. They are then copper plated to allow the soldering on of copper wire leads. A platinum grid completes the assembly. After all wires and connections, except the grid, have been insulated, the assembly is immersed in the electrolyte (5 per cent sodium tetraborate and boric acid solution) and hermetically sealed in a small glass tube to avoid electrolyte evaporation.

Small size (Fig. 1) is required to give high-frequency operation. The smallest units constructed so far use crystals about 0·3 mm long, and 0·15 mm in "diameter." It is expected that by going to a flat plate crystal instead of the rod geometry, the present low output power levels could be raised appreciably, without any over-all increase in size, or any change in other operating characteristics.

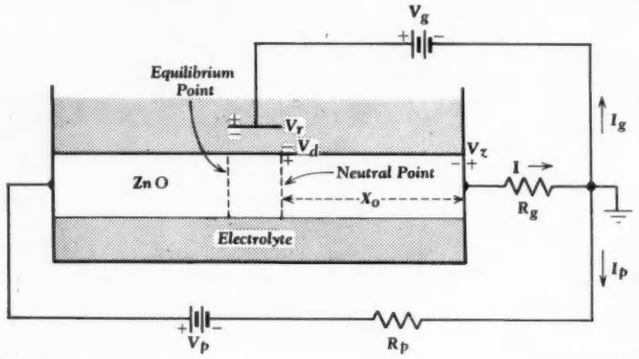
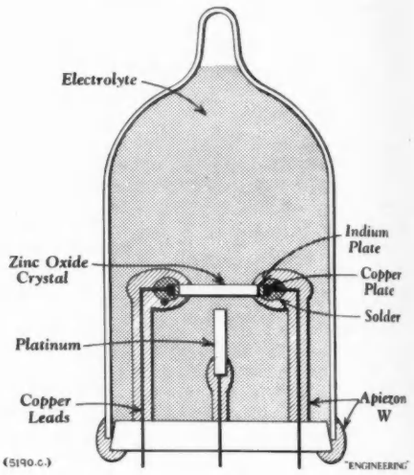


Fig. 2 (left) The drawing of the device shows the position of the platinum "grid" in relation to the main crystal.

Fig. 3 (right) As the equilibrium point shifts back and forth under the influence of varying biasing grid voltages, the resistance of the crystal changes.



Continuing **Dynamic Calibration**

machine.[4] The use of a vibrator operating at a frequency differing from that of the fatigue-testing machine does, however, have the advantage that the machine waveform can be inspected when making the calibration (see Fig. 3 (*c*)).

The use of a bridge energised by direct current has a number of advantages over the use of bridges fed with carrier current.[5, 6, 7] No capacitive balance is required, filters are not required to eliminate harmonics present in the bridge output, and a much clearer trace of the load cycle is obtained on the cathode-ray tube. The circuit details described are capable of wide variations, both in the power supply and in the pre-amplifier, which should be designed for the particular oscilloscope available. The method is applicable not only to the calibration of direct-stress fatigue machines but is directly applicable to the measurement of periodic strains. The apparatus has, in fact, been used for the measurement of periodic strains in parts subjected to bending, torsion, tension and compression. Where a static calibration of these parts is not possible the accuracy of measurement is primarily limited by the accuracy to which the gauge factor is known.

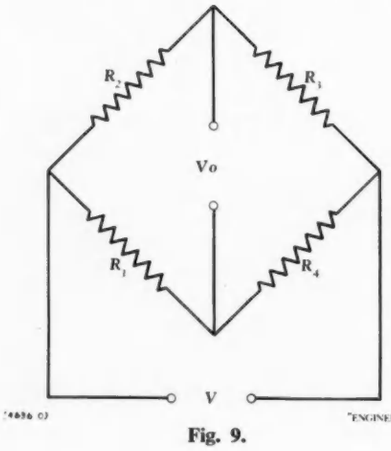


Fig. 9.

APPENDIX

If, in Fig. 9, R_1 and R_4 are strain gauges, the resistances of which change by small amounts ΔR_1 and ΔR_4 respectively, it can be shown that

$$\Delta Vo = \frac{\partial Vo}{\partial R_1}\Delta R_1 + \frac{\partial Vo}{\partial R_4}\Delta R_4$$

$$= \frac{R_1 R_4}{(R_1 + R_4)^2}\left(\frac{\Delta R_1}{R_1} - \frac{\Delta R_4}{R_4}\right)$$

provided that no current is drawn from the output.

If $R_1 = R_4$ (condition for optimum bridge sensitivity)

$$\frac{\Delta R_1}{R_1} = K e_1 \text{ and } \frac{\Delta R_4}{R_4} = K e_4 \text{ where } e_1$$

and e_4 are the strains producing the resistance changes ΔR_1 and ΔR_4 respectively; then

$$\Delta Vo = \frac{V}{4} K (e_1 - e_4).$$

When the measured strains occur on opposite faces of a bar subjected to combined bending and direct stresses $e_1 = e_d + e_b$ and $e_4 = e_d - e_b$ where e_d = direct strain and e_b = bending strain. $\therefore\ e_1 - e_4 = 2e_b \quad \therefore\ \Delta Vo = \frac{V}{2} K e_b$;

i.e., the bridge output is proportional to the bending strain on the test bar.

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[3] Attree, V. H. *Electronic Engineering*, pp. 174 to 177, April, 1955.
[4] Gustafsson, G. V. A., and Olsson, Carl Olof. Aeronautical Research Inst. of Sweden, Report 63.
[5] Grover, H. J. The Society for Experimental Stress Analysis, Proceedings, vol. 1, No. 1, (1943.)
[6] Littlewood, J. H., and Maskery, C. ENGINEERING, vol. 175, pp. 350 to 352, 13 March, 1953.
[7] Roberts, M. H. *Metallurgia*, vol. 46, No. 274, pp. 107 to 114, August, 1952.

Acknowledgments.—The author acknowledges the assistance of Mr. J. Mackinnon in the construction of the equipment. The work described has been carried out as part of the research programme of the Mechanical Engineering Research Board, DSIR, and the article is published by permission of the Director.

NPL RESEARCH

Wind-tunnel Studies *Anti-Vibration Mountings* *Computer that Learns*

Examples of the wide range of work carried out at the National Physical Laboratory have been on view recently, on two "open days." The NPL, in addition to its vital task of establishing and maintaining standards of measurement, regards itself primarily as a pioneering research institution, paving the way for future industrial development. As well as conducting fundamental research, however, the NPL also undertakes commissioned investigations to solve specific problems, and provides an advisory service for industry, the universities and others.

This year there have been certain changes in the set-up: the old Electricity, Metrology and Physics divisions have been dissolved, mixed and reconstituted as the Standards, Applied Physics and Basic Physics divisions. The primary responsibility of the Standards division is to provide the basic standards of length and mass, time-interval and frequency electromagnetic quantities and temperature; standards of angular measurement, barometric pressure and hardness, and various other derived quantities and physical constants.

Whereas the Basic Physics division is concerned with long-term projects in heat and thermodynamics, the strength of materials, ultrasonics and elasticity, high pressures (up to 4,000 atm), and low temperatures, the Applied Physics division aims to serve the needs of industry and scientific workers for precise calibrations and special investigations in fields such as heat, electrotechnics, acoustics, and radiology. Typical of such special investigations is the measurement of the stored energy in actual graphite samples taken from the Windscale atomic pile, using a bomb calorimeter of orthodox design—that is, briefly, a strong steel "bomb," in which the sample is burnt, immersed in a vessel of stirred water. The temperature rise is measured very accurately, and with a knowledge of the total heat capacity of the calorimeter, the heat of combustion of the sample is determined. The difference between the value obtained for each irradiated graphite sample and that obtained for unirradiated graphite is a measure of the stored energy in that sample.

ANTI-VIBRATION MOUNTINGS

Another investigation which promises to yield unexpected results, of interest to all engineers concerned with the installation of machinery or instruments, relates to the effectiveness of anti-vibration mountings, both commercially available mounts using cork, rubber, or steel springs, and NPL-designed composite spring mounts with varying degrees of damping.

Although the theory of vibration isolation is well established, there is as yet only a limited amount of information in the literature on the actual performance of anti-vibration mounts when in use, and in particular on mounts intended to isolate sensitive apparatus from low-frequency mechanical vibration. The Physics division has developed the arrangement shown in Fig. 1 for generating controlled disturbances to assess the effectiveness of an anti-vibration mount. The results obtained so far suggest that anti-vibration mountings employing as the insulating medium rubber or cork—and particularly the latter—fall well short of their theoretical performance at the lower frequencies.

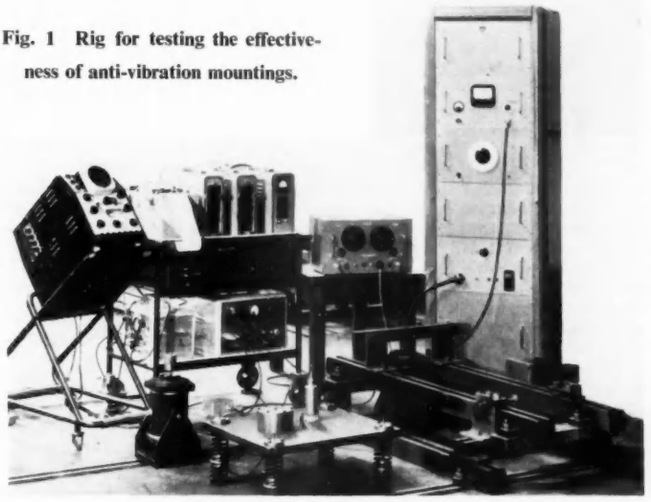

Fig. 1 Rig for testing the effectiveness of anti-vibration mountings.

WIND PRESSURE ON STRUCTURES

The work of the NPL's Aerodynamics division benefits not only the aircraft engineer but also the structural engineer and the shipbuilder. Its investigations into the aero-elastic behaviour of suspension bridges under wind loads are now well known; similar investigations have been carried out for the BBC's television transmitting tower at the Crystal Palace and for the bowl-shaped aerial of the Jodrell Bank radio telescope, which have resulted in modifications in the design of the latter to avoid wind-excited oscillation at certain elevations. The division has also carried out wind-tunnel tests on the static wind loading on structures similar to those of some houses on a Hatfield housing estate: unfortunately, the tests were made after the houses had already lost their roofs in a gale last year. (The results of tests on other roof forms, including single-pitch roofs, were already well known and the subject of a British Standard).

The design of ships' superstructures may now be made with due regard to the airflow that will be experienced in service. For example, it is desirable that the effluents from funnels and ventilators are kept clear of the superstructure and that bridges and passenger decks are free from downdraughts. These conditions can be studied and improvements sought by experiments with models in wind-tunnels. Such experiments have been made for the P. and O. Company's Canberra and the Orient Line's Oriana. Similar problems also occur on land and experiments can be carried out to determine the extent of any pollution that might arise because of incorrectly sited or designed chimneys. An investigation has been carried out for the building now being erected for the Shell Group on London's South Bank.

HYPERSONIC FLOW

The Aerodynamics division's investigations into hypersonic flow may help to bring about the successful accomplishment of space travel within the lifetime of, at any rate, the younger generation of engineers. Hypersonic flight introduces a number of new physical problems resulting from the extremely high temperatures produced—for example, the temperature of the air surrounding a missile flying at Mach 4 will exceed 4,000° C. At such high temperatures, transient techniques have to be adopted. For studying heat transfer problems the NPL has at present in operation a 3 in diameter hypersonic shock tube designed to operate at pressures up to 200 atm with an expanded evacuated working section of 15½ in diameter, in which a Mach number of 9 is attainable at altitudes down to 150,000 ft; the duration of steady flow is of the order of 100 microseconds. A high-speed Cranz-Schardin camera, taking eight successive pictures at a rate

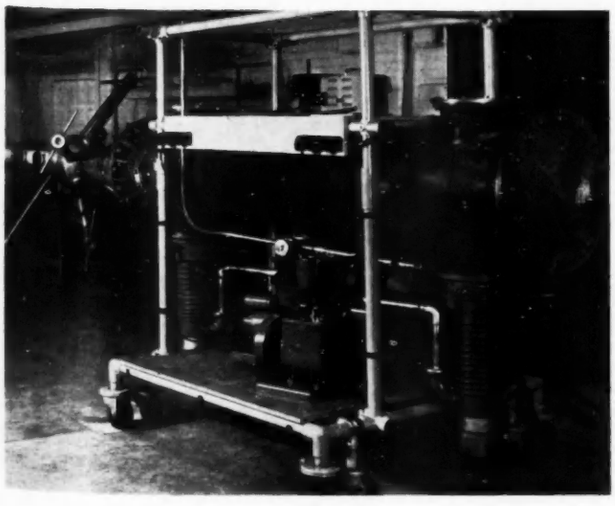

Fig. 2 (left) The hypersonic working section and high-vacuum plant of the 3 in shock tube.

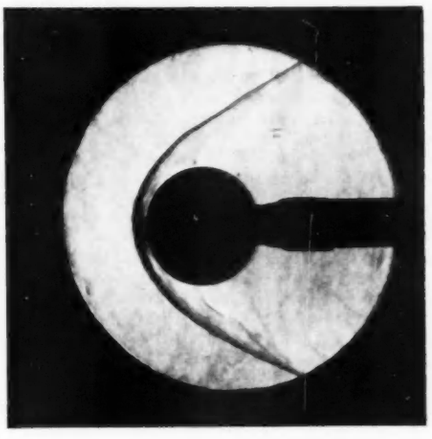

Fig. 3 (right) A photograph, taken by Cranz-Schardin camera and Schlieren optical system, of the flow past a sphere mounted in the hypersonic shock tube—approximate speed Mach 9, altitude 150,000 ft, stagnation temperature 6,000° K.

Continuing Research and Development

of 300,000 frames per sec, is used in conjunction with a Schlieren optical system to record the flow patterns; the operation of the camera, and of the timing system for recording the sequence of events, is triggered by the passage of the shock wave along the tube. A typical Schlieren photograph is shown in Fig. 3.

The 3 in shock tube—now in use as a research tool in its own right—was originally conceived as a pilot model for a 6 in shock tube now being constructed. This larger installation, designed to operate at pressures up to 1,000 atm, will make it possible to simulate speeds of Mach 9 at altitudes down to 80,000 ft in the expanded working section. Two smaller shock tubes have been built for studying dissociation and ionisation effects in high temperature gases. One will be used to study spectroscopically the visible radiation of such gases, with a view to determining the temperature; the other to study the interaction between the gas and microwave beams in order to measure the electron concentrations.

AREA-RULING

If Britain's hypothetical supersonic airliner achieves successful fruition, it may well be in part due to the efforts of the NPL's aerodynamicists. Over the past few years, in both this country and the United States, considerable effort has been devoted to research to determine means of delaying and reducing the marked rise in the drag of an aircraft that occurs as its speed approaches that of the speed of sound. In the United States, Whitcomb and his colleagues, of the Langley Aeronautical Research Laboratory, have formulated the " area rule " in which the flow around the aircraft is treated as a whole. In this country, at the Royal Aircraft Establishment at Farnborough, Dr. Küchemann and his colleagues have sought the solution of the problem by considering, in detail, the flow around the junction of the wing and body and the wing-tips (where most of the drag is generated); they have then tried to lessen this drag-rise by making local modifications to the body or wings. Both these methods are yielding promising results.

The NPL has been carrying out research in this field for some time. A comprehensive series of tests on a typical swept-back wing at transonic speeds has provided a valuable basis of knowledge, upon which research to find further improvements is now being planned. This same wing has also been tested, fitted with a range of various bodies. In particular, it has been found that, while indenting the body symmetrically above and below its junction with the wing improves conditions at zero incidence, even better results are obtained at an incidence corresponding to typical cruising conditions if less indentation is made *below* the wing.

A second series of tests is to begin, using a simple model of a complete wing-body. These tests will incorporate the use of several body shapes, and will provide further fundamental information on the sonic " area rule " and its extension to supersonic speeds. Further research has included the theoretical development of a wing planform with which it is hoped to reduce the areas of excessively high suction that occur near the tips of conventional tapered wings at both transonic and low speeds.

An alternative method of achieving low drag at supersonic speeds is to use an " all-wing " configuration, and it is thought that a slender wing of delta planform may prove suitable.

METALLURGY AND MACHINE CONTROL

In the metallurgical division, early investigations into the resistance of steels to thermal fatigue—a problem of interest to power stations which are operated intermittently—have suggested that ductility is a more valuable factor against thermal fatigue than strength; and studies of the interfacial energies in copper-antimony alloys are expected to throw light on the mechanism of brittle fracture. Other facets of the NPL's work which are likely to affect industrial trends are new photographic methods for producing accurate diffraction gratings,

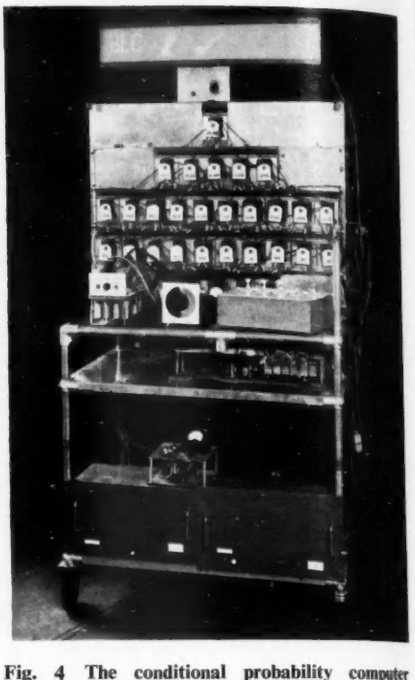

Fig. 4 The conditional probability computer which can learn from experience.

several feet long, for the automatic control of machines; and the development of a " conditional probability computer "—that is, a machine which " learns by experience " (Fig. 4)—from which it is hoped to develop an industrial control mechanism which will optimise its control function by a trial-and-error learning process. A machine of this type—which is the first step towards a computer capable of exercising judgement, as opposed to doing what it is told—is to be installed experimentally in an oil refinery in South Wales.

TOWARDS DYNAMIC PROCESS CONTROL

We give below an extract from the Presidential Address to the Society of Instrument Technology, delivered last week by Sir Harold Hartley, G.C.V.O., F.R.S., under the title " The Place of Instrument Technology in Control Engineering." Reference is made to Sir Harold's views on the importance of control engineering in Weekly Survey.

Control engineering is a means to an end—the more efficient and economical operation of any engineering project. Instrumentation is the key to control engineering—defining " instrumentation " in its broadest sense to include not only measuring elements, but also the transmission of measurements to the control units, and the mechanisms by which the output signals of the controller exercise the ultimate control of a plant.

Hitherto control in the process industries has been exercised almost entirely by a number of independent automatic controllers having some combination of the proportional, integral and derivative actions, each controller operating through the measurement of a single variable which it maintains at a set value based mainly on previous experience. The value can be altered by the operator as circumstances require. This can be regarded as the static phase of control. New methods for the rapid measurement of the composition variables now open up the possibility of the dynamic control of a plant similar to that of a guided missile, or the launching of a satellite, when the various factors influencing its performance are integrated by means of a special-purpose computer.

This new phase in the development of process control is in its infancy. The control of chemical compositions is a much more complex task than that of a machine, where each of the physical characteristics is susceptible to a direct single control. The adjustment of chemical composition, on the other hand, will involve a number of independent variables, such as temperature, pressure, time of residence, catalyst activity and feedstocks, and the optimisation of the conditions in the plant is a much more complicated problem. Clearly progress will depend on the investigation of the dynamic characteristics of the processes concerned, in which instrumentation must play a major part.

The possibility of devising a self-optimising system has been greatly advanced by the recent developments in data-processing equipment. The growing complexity of industrial plants and the increasing number of automatic control loops has led to the need for a centralised control room which, in addition to the conventional panels of instruments, has a data logger, or perhaps a scanning system to draw attention to the off-normal values. The data logger, in addition to checking each signal against high and low-limit signals and indicating off-normal values, would record the output data in digital form, thus acting as a central recorder to the existing control loops.

It is, however, inherently improbable that the present system of controlling each single variable by a single factor in isolation from all the rest is the best one, when each may be affected by, and affect, other control loops in the system. If the reactions of the different variables on one another were known, the data logger is the first step towards an interlocking self-optimising system: the signal centralised in the data logger could be interpreted by a special-purpose computer, which would issue the appropriate signals to the control mechanisms. It could either send messages to the existing controllers or, at a later stage, it would communicate direct with the final control elements, such as the control valves, thus simplifying the whole control system. If the calculations were too involved, the computer might be provided with a memory which would enable it to adopt a trial-and-error system of adjustment in certain cases.

The immediate problem on which progress will depend is the investigation of the response of the system to disturbances of various kinds with a view to optimising its performance. The analysis of the results of data-logging over a period offers one possibility of discovering co-ordination between the variables, but it may be too restricted in its range. Introducing known disturbances is the most hopeful method of attack.

Investigation alone can evaluate the economic advantage likely to result from such a dynamic system and to what extent a special-purpose computer should take over the control. Much can be done in the present phase of static control to investigate the characteristics of existing processes, and thus prepare the way for the design of future systems of dynamic control. Simplified computers for such purposes have still to be designed, probably of a mixed analogue-digital type to give the advantages of both. Progress will depend on co-operation between the industrial users who possess the operating experience and opportunities, and the instrument makers who provide the tools.

MALVERN MASER

Development of molecular amplifiers, or masers, is being carried out at the Royal Radar Establishment, Malvern. One project is concerned with producing an amplifier for attachment to the 45 ft radio telescope there. Waves in the 10 cm band are being studied and it is possible that a molecular amplifier, by virtue of its extremely low internal noise level, might increase the sensitivity of the equipment by a factor of about 100. Amplification in solid crystals at microwave frequencies has been obtained at the establishment, but development must proceed before the apparatus is suitable for use outside of the laboratory.

The term " maser " is derived from the initials of " microwave amplification by stimulated emission of radiation." The active solid used is commonly a single crystal containing a paramagnetic salt such as gadolinium ethyl sulphate or potassium chromi-cyanide. Operation is restricted to temperatures near absolute zero. Fairly large crystals, having a volume of several cubic centimetres are required and they must have good crystalline form. One of the development problems is the growing of such crystals with the required amount of the paramagnetic salt. The low temperature operation presents further engineering problems.

The crystals are grown by slowly dropping the temperature of an aqueous salt solution at a rate dependent on the solubility of the salt, the surface area of the crystal, and the volume of the solution. Electronic temperature control is used. It is necessary to produce a crystal lattice that will space the paramagnetic ions (gadolinium or chromium, in the crystals already mentioned) far enough apart to prevent their interaction.

The crystal is kept in constant motion in the tank by attaching it to the end of a rotating arm. Temperature control is maintained electronically to $\pm 0{\cdot}05^\circ$ C.

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For this reason, the crystals contain a small percentage of the paramagnetic salt and dilution is obtained with a diamagnetic or nonmagnetic salt which crystallises with the same structure. Another example of the type of salt under study is a mixture of alums having the formulae

$$(NH_4)_2\,SO_4 \,.\, Al_2(SO_4)_3 \,.\, 24\,H_2O$$

and

$$(NH_4)_2\,SO_4 \,.\, Fe_2(SO_4)_3 \,.\, 24\,H_2O$$

The ratio of aluminium to iron is 199 : 1. When crystals of this substance are being prepared, the temperature of the solution falls by $0{\cdot}2^\circ$ C per day when the crystal is small, the rate increasing to $0{\cdot}5^\circ$ per day as the crystal grows larger. The crystal growing equipment is shown in the illustration. A total period of growth of 10-14 days is usual, and throughout the period a critical control of temperature to $\pm 0{\cdot}05^\circ$ C is maintained.

In practice, the growing point of the solution is determined by immersing a test crystal in the solution and raising the temperature until the crystal starts to dissolve. Then the seed crystal, which the main growth is made on, is immersed and the temperature control started. The seed is kept in constant motion in the solution, and for a period of about 12 hours it slowly dissolves. This exposes a clean surface on which to start uniform growth, which is initiated and continued until the crystal is of sufficient size for insertion into a microwave cavity.

NOTICES OF MEETINGS

British Computer Society

LONDON
Annual General Meeting and Presidential Address. Northampton College of Advanced Technology, St. John Street, E.C.1. Mon., 16 June, 5.30 p.m.

Chemical Society

LONDON
Faraday Lecture: " The History of the Isoprene Rule," by Professor L. Ruzicka. Imperial College of Science and Technology, South Kensington, S.W.7. Thurs., 5 June, 7.30 p.m.

Combustion Engineering Association

GLASGOW
Discussion on " A Survey of Boiler Cleaning Methods," at 10.30 a.m. and a Discussion on " A Comparison of Space Heating Systems," at 2.30 p.m. Scottish Region. Grand Hotel, Charing Cross, Glasgow, C.3. Wed., 11 June.

Helicopter Association of Great Britain

LONDON
" Turbine Helicopters," by D. L. Hollis Williams. Royal Aeronautical Society, 4 Hamilton Place, W.1. Fri., 6 June, 6 p.m.

Incorporated Plant Engineers

LONDON
Debate on " In Planning a New Factory the Plant Engineer and Not the Architect Should Have the Final Authority." London Branch. Royal Society of Arts, John Adam Street, Adelphi, W.C.2. Tues., 3 June, 7 p.m.*

Institution of Civil Engineers

LONDON
Annual General Meeting. Tues., 10 June, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Institution Conversazione. Royal Festival Hall, S.E.1. Wed., 25 June, 7.30 p.m.

Institution of Engineering Designers

LONDON
" Engineering Design: The Background and Basis of Contemporary Life," by Hugh Clausen. Manson House, 26 Portland Place, W.1. Thurs., 12 June, 6.30 p.m.

Institution of Mechanical Engineers

CARDIFF
" Light Mechanical Engineering in South Wales," by H. A. V. Bulleid; and " Some Mechanical Equipment in the Heavy Industries of South Wales," by W. F. Cartwright and I. S. Scott-Maxwell. Ordinary Meeting of the Institution. Rearden Smith Lecture Theatre, Cardiff. Wed., 18 June, 10 a.m.

Institution of Public Health Engineers

LONDON
Informal Discussion Meeting. Caxton Hall, off Victoria Street, S.W.1. Mon., 2 June, 6 p.m.
Summer Meeting. Annual General Meeting, at 4.45 p.m. Tea at 5.15 p.m. Discussion on " The Hogsmill Valley Works of the Hogsmill Valley Joint Sewerage Board," at 6 p.m. Caxton Hall, off Victoria Street, S.W.1. Fri., 13 June. (A visit to the Hogsmill Valley Works, near Surbiton, Surrey, will be paid on Saturday morning, 14 June.)

Royal Institution

LONDON
" Drilling Deep Holes into the Earth," by Dr. T. F. Gaskell. Wed., 11 June, 9 p.m.

Royal Meteorological Society

LONDON
Various short papers including " The Use of Balloons in Atmospheric Pollution Research," by D. H. Lucas, G. Spurr and F. Williams; and " The Hydrogen Content of Atmospheric Air at Sea," by E. Glueckauf and G. P. Kitt. Wed., 18 June, 5 p.m.*

Royal Society

LONDON
" Structure of Chromium Potassium Alum," by G. E. Bacon and W. E. Gardner; and " Moiré Patterns on Electron Micrographs and Their Application to the Study of Dislocations in Metals," by G. A. Bassett, J. W. Menter and D. W. Pashley. Thurs., 5 June, 4.30 p.m.*

Women's Engineering Society

MANCHESTER
Annual General Meeting and Film Evening. Manchester Branch. International Club, George Street, Manchester. Wed., 11 June, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

British Computer Society, 29 Bury Street, St. James's, London, S.W.1.
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke Street, St. James's, London, S.W.1. (WHItehall 5536.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, S.W.1. (ABBey 5160.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland Place, London, W.1. (LANgham 8847.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Public Health Engineers, 118 Victoria Street, London, S.W.1. (VICtoria 3017.)
Royal Institution, 21 Albemarle Street, London, W.1. (HYDe Park 0669.)
Royal Meteorological Society, 49 Cromwell Road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Women's Engineering Society, 25 Foubert's Place, London, W.1. (GERrard 5212.)

IGNITRON OR EXCITRON?

Radar added words such as magnetron and klystron to the British vocabulary, and to-day the Greek neuter noun-ending has even penetrated into the railway world. Locomotive engineers must now not only be familiar with ignitrons and excitrons, but prepared to choose between them, for these two types of single-anode mercury-arc rectifier will for some time be key components in the design of electric locomotives and motor coaches for high-voltage single-phase traction at 50 c/s.

So far the ignitron has predominated, largely because the extinction of the arc in non-conducting half-cycles tends to make backfires less likely and permits close spacing of anode and cathode, resulting in a small rectifier with a low arc-drop. Excitation circuits, however, are somewhat more complicated than in the excitron rectifier with its continuously-maintained arc, and the baffles used in the ignitron to limit backfires increase the arc-drop to some extent. Much research has been directed towards the development of a really small excitron with as much immunity from backfires as can be expected in an imperfect world, while improving on the ignitron in its arc-drop characteristics. One result of this work is the " Com-Pak " single-anode rectifier demonstrated recently by the G.E.C. at the Hanover Trade Fair.

In the G.E.C. design the techniques adopted for anchoring and cooling the cathode spot have enabled the dimensions of the cylinder to be kept very small with safety, and, in reducing the requirement for baffles, have allowed maximum advantage to be derived in respect of low arc-drop from the small anode-to-cathode spacing. Anchoring is effected by inserting a metal electrode into the mercury, so that the cathode of the arc locks at the junction of the meniscus of the mercury and the anchor. The principle is well known, but its successful application in a power rectifier is a step forward. The rectifiers are to be incorporated in the electric locomotives and motor coach equipments which the G.E.C. is supplying to British Railways.

Book Reviews

MATERIALS AND BOND

Symposium on Structural Sandwich Constructions. ASTM Special Technical Publication No. 201. *American Society for Testing Materials*, 1916 *Race Street, Philadelphia* 3, *Pa., U.S.A.* (Members 2 *dol*, non-members 2·75 *dol.*)

This volume is the published account of the proceedings of a conference held in Los Angeles in September 1956 (not 1957 as stated in the foreword) to discuss sandwich construction for structural purposes. Certainly the holding of a specialised symposium of this type is in itself an event of interest to those directly concerned with metal-bonding adhesives and honeycomb, and perhaps one must expect the papers to have a heavy bias towards the rather insular approach of the testers and adhesive formulators. However, the value of the publication (and, one might suggest, of the conference itself) would, one feels, have been much enhanced by the addition of more papers from the aircraft or structural designer's viewpoint; these latter will find some of the present volume (especially "Sandwich in the Design of Helicopters," by Jay M. Stevens) worth reading, but will be disappointed in much of the remainder. Inclusion of the discussions is a most commendable endeavour, but both the discussions and their reporting are not of a particularly high standard.

From the point of view of those concerned with developing structural adhesives and honeycomb, there is matter of considerable interest. The paper by Sheridan and Merriman on "Empirical Studies of Bonded Joints for Sandwich Construction" presents data selected from the large amount of test work conducted by the Martin aircraft company and there is a careful assessment by the authors of the effects of joint parameters on strength. A paper on the selection of materials for architectural sandwich panels points the way for this form of construction for non-aircraft uses and draws attention to the great possibilities in this field.

Other papers of particular note are: "Recent Developments in Sandwich Construction, Including Heat-Resistant Materials," by Roger C. Steele and Andrew C. Marshall in which is presented the opposite end of the story to that discussed by Parkinson, much interesting data being given on the development of sandwich materials for service in aircraft at temperatures up to 1,500° F, and "Methods of Testing Sandwich Constructions at Elevated Temperatures," which describes some typical test procedures used by the Forest Products Laboratory, who are perhaps the leaders in theoretical and testing work in this field.

The production engineer will also find interest in the papers by James S. Arnold and Richard E. Anderson on the non-destructive testing of bonded structures by ultrasonic techniques. Although experience in England has shown that entirely satisfactory results can be achieved by bonded structures without these advanced testing methods, it is true that a non-destructive test method is most desirable. The work on the "Stubmeter," described by Arnold, is perhaps the most promising at present being undertaken, but clearly it has some way to go before it is a useful inspection instrument for the detection of sub-standard bonds, as opposed to the complete lack of bond.

Summarising, then, it can be said that it is a volume of interest to those working in this increasingly important though specialised field, but of only limited value to the designer concerned with a wider range of problems.

NEW BOOKS

The Aeroplane Directory of British Aviation. 1958 Edition. *Temple Press Limited, Bowling Green Lane, London, E.C.*1. (30*s.*)

A larger section devoted to aircraft and engine constructors in order to accommodate particulars of the numerous guided weapons departments now in being is probably the major revision incorporated in this year's Aeroplane Directory—and the greater emphasis on guided weapons is also reflected in the reduction of the establishment of R.A.F. Fighter Command.

In general the Directory follows the well-established form, comprising sections on service aviation; civil ministries and establishments; the aviation industry; commercial aviation; international bodies, learned bodies, professional societies and clubs; the aeronautical press; aeronautical training; "who's who" in British aviation; obituary; a list of abbreviations; a list of commercial licences, a general names index and a trade names index.

Readers of ENGINEERING will most probably find the comprehensive section on the aviation industry of greatest use. It is, in fact, practically indispensable to anyone in any way concerned with aeronautics. This is subdivided under headings such as aircraft constructors, aero-engine constructors, holding companies, foreign licensees, consultants, sales and service agents, metallic materials, prefabricated components and parts, controls, systems and accessories, radio and electrical equipment etc.—a somewhat tiresome arrangement since the sections are not readily identified and, also, it is not always obvious which section to look up; for instance, whether a certain item is to be considered a "prefabricated" component or an "accessory." However, the material is all there to be found.

Engineering Materials Handbook. Edited by CHARLES L. MANTELL. *McGraw-Hill Book Company Incorporated*, 330 *West* 42*nd Street, New York* 36, *N.Y., U.S.A.* (21 *dol*); and *McGraw-Hill Publishing Company Limited*, 95 *Farringdon Street, London, E.C.*4. (167*s.*)

The main object of the editor and of the 150 contributors to this bulky handbook is to furnish practising engineers, designers, students and architects with authoritative data on engineering materials. There are 43 sections or chapters, each dealing with a particular material, or range of materials, and each written by one or several specialists on the subject. Emphasis is laid on the fabricated forms of materials, their physical and mechanical properties, their adaptations and their advantages and limitations.

Polyethylene: Reinhold Plastics Applications Series No. 1. By THEODORE O. J. KRESSER. *Reinhold Publishing Corporation*, 430 *Park Avenue, New York* 22, *N.Y. U.S.A.* (5 *dol*); and *Chapman and Hall Limited*, 37 *Essex Street, London, W.C.*2. (40*s.*)

Without going into great technical detail, the author shows how polyethylene is produced and how it is made into useful articles. The book, however, is primarily concerned with the applications of polyethylene. The subject is dealt with in a practical and selective manner and each application described represents a group of related applications. The information conveyed is brief and concise and particular consideration is given to non-technical readers.

Centrifugal and Axial Flow Pumps, Theory, Design and Application. By A. J. STEPANOFF. Second Edition. *John Wiley and Sons Incorporated*, 440 *Fourth Avenue, New York* 16, *N.Y., U.S.A.* (12 *dol*); and *Chapman and Hall, Limited*, 37 *Essex Street, London, W.C.*2. (96*s.*)

Revisions and additions have been made to include the progress that has been made in the design of centrifugal pumps, but the same general approach has been followed. It is essentially a book for the designer and lists of references are given at the end of each chapter.

Concise Guide to Plastics. By HERBERT R. SIMONDS. *Reinhold Publishing Corporation*, 430 *Park Avenue, New York* 22, *N.Y., U.S.A.* (7 *dol*); and *Chapman and Hall Limited*, 37 *Essex Street, London, W.C.*2. (56*s.*)

Without going too deeply into details on any particular subject, the author has endeavoured to give his readers useful data regarding the plastics industry as a whole. The book contains instructions on the selection and use of plastics in various forms and gives guidance on which to select for particular applications. Basic data on properties and processes, production, and mechanical properties and prices are included.

On the Shelf

By Frank H. Smith

An *Information News-Sheet* put out by the Islington Public Libraries encourages the fellowburghers of John Gilpin to use their reference library. At the foot of a page indicating the wealth of reference literature available it says "If there is printed information available the reference librarian knows where to get it." That's the sort of unequivocal remark I like to see and, judging from the sample questions that are quoted, that omniscient gentleman certainly gets some snorters.

A little while ago I thought to myself "I do not seem to have heard from Dover (publications) for a long time" and then, two days later, I received from Constable, 10-12 Orange Street, London, W.C.2, a handsome catalogue of the Dover range for which they are now, it seems, the agents in this country. I have said before, in this column, what a good thing these Dovers are and I commend the catalogue to the comparatively impecunious and those searching for standard text-books which they think may be out of print. It is a funny thing but, translated into shillings, they do not seem quite so cheap as they did in dollars and cents. But they still are cheap.

The April number of the *Proceedings* of the Institution of Civil Engineers has an interesting feature giving the histories of the various prizes, medals and premiums awarded by the Institution.

Those librarians who like to check whether they have all the publications of the American Society of Mechanical Engineers, likely to be useful to their members, will be pleased to hear that the "1958 listing" is now available from 29 West 39th Street, New York 18. Latest (1957 plus) publications are indicated by an asterisk.

The *Unesco Bulletin for Libraries* for April reviews the meeting on the Unesco agreement on the importation of educational, scientific and cultural materials. Fifty-two states were there. Twenty-six are now parties to the agreement (which, largely, favours duty-free importation of the material cited). These 26 are listed in a footnote to the article and it is a matter for pride that the United Kingdom is among them. It is a matter for surprise that the U.S., both A. and S.R., are not.

The recently-formed Society of Indexers has produced No. 1 of Volume 1 of *The Indexer*. An amusing feature is "No Index—No Comment" which is introduced thus: "This is not a complete list, but merely the books we have been able to trace which have been published without an index in the period July-December, 1957. We shall continue to include similar lists in *The Indexer* until the necessity for it ceases." While such a threat will not influence the sales of the books listed, such a list may well make publishers realise how important it is that no indexable book should appear without an index.

Consultants Bureau Inc., 227 West 17th Street, New York, U.S.A., are producing, in May, the first number of *Express Contents of Soviet Journals*. This aims to put the contents lists of 39 Soviet journals on your breakfast table about two months after they are published for the Russian breakfast table and about two to six months ahead of the complete translation. I would suggest that anybody who is interested should write to the address I have given.

Europa Publications, 56 Bloomsbury Street, London, W.C.1, go in for encyclopaedic publications and they are producing (May) a second edition of *The British Commonwealth* at £6. Descriptive material can be obtained from the address quoted.

I have only just noticed that *Government Publications*, the monthly catalogue of what can be bought from H.M. Stationery Office, is appearing with different hued covers for each month this year. Previously only the titling and the crest on the cover have been changed each month.

Design

CONTROLLING LARGE MOTORS BY MERCURY ARCS

Up till now, mill rolls have been controlled with motor-generator sets. These have shown good reliability and satisfactory performance. However, English Electric Company Limited suggest that systems using mercury arc converters can be used instead; development of mercury arc units has now made them reliable enough for such work. The converters could also be used with mine winders. In the basic system, grid-controlled mercury arc converters feed direct current motors, and the circuits producing the grid voltage are used to control motor speed and direction. During braking, the converters invert the direct current output from the motors and return power to the alternating current supply. The firm say several advantages are to be expected: lower first cost, lower installation costs, greater efficiency over the normal working load range, lower light load losses, and no addition to the fault level of the a.c. system.

But the supply system must be of sufficient capacity. Mercury arc converters demand an electrical power input that follows closely the mechanical power requirements of rolling. The peak load must not cause sufficient voltage drop in the external power supply to interfere with other consumers' equipment. Previously, direct current mill motors have been fed from motor-generator sets, sometimes driven by synchronous motors, but more often by induction motors—frequently using a flywheel to smooth out the heavy load peaks. The synchronous motor drive provides the facility for power factor correction, which the mercury converter lacks. On the other hand, peak loads suddenly imposed on the d.c. motor result in load overswing on the a.c. system, owing to the inertia of the synchronous motor. This might amplify the peak load demand to a level that results in undesirable voltage dips on the a.c. system. In this respect the mercury arc converter occupies an intermediate position between the synchronous motor set and the flywheel or Ilgner set. The mercury arc converter simply reflects on the a.c. system an accurate reproduction of the load.

Care must also be taken to ensure that the mercury arc converter does not distort the supply waveform. When the d.c. power from the braking mill motors is converted to a.c. power, a wide range of harmonics of the supply frequency is generated. If the high frequency components are allowed to reach an undesirable intensity they can cause overheating of static condensers, telephone interference, and maloperation of ripple controls. Usually harmonic currents can be kept to a low level by phase multiplication, the need for which is determined by the size of the converter in relation to the a.c. system feeding it.

DEMONSTRATION

To show the degree of control obtainable in large reversing mill drives, the company recently demonstrated a system able to handle over 4,000 A at speed changes approaching 500 r.p.m. per sec. In the demonstration there was no actual rolling and the full machine capabilities were available for acceleration and deceleration. The set consisted of four d.c. machines connected in series-parallel and a synchronous machine that could either be used as a motor or an alternator. A base speed of 300 r.p.m. and a top speed of 600 r.p.m. were chosen, the latter being obtained by field weakening. The working voltage was 460 V. The d.c. machines had solid frames. Field weakening and strengthening was therefore typical of many machines on rolling mills, although the field response times were made as fast as possible within the limits of the existing machine designs. The converter consisted of three standard pumpless steel tank mercury arc units in their cubicles. Hence the nominal rating of the converter equipment at 460 V was 2,250 A, 1,035 kW.

Two types of converter connections were demonstrated—armature reversal, and field reversal. A third method using cross-connected converters is possible, but as it entails the use of two sets of converter equipment it is more expensive than the two methods demonstrated. It is necessary when rapid and continuous speed control of high inertia drives is wanted.

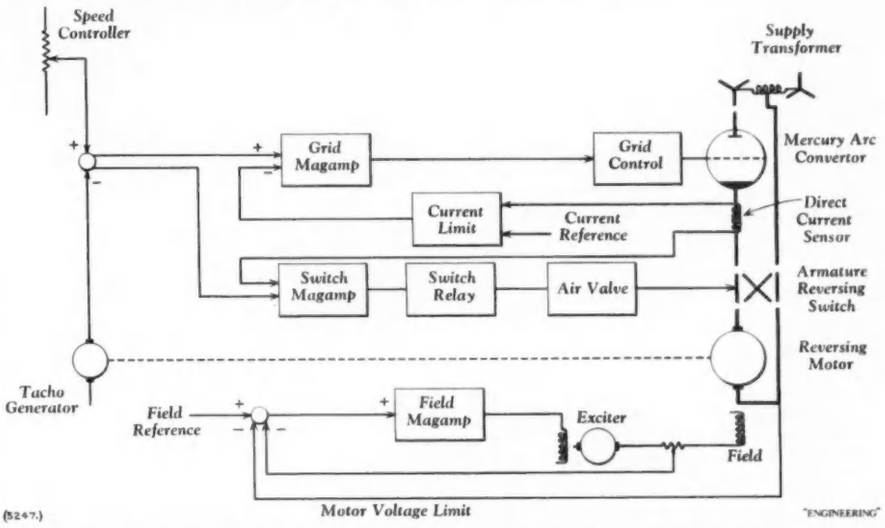
With the rather less exacting requirements of reversing mills and some winders where a short period of " dead " time (about 0·3 sec or longer) is tolerable, it is possible to use only one converter. However, because the converter can pass current in one direction only it becomes necessary to reverse the motor polarity when changing from motoring to braking. This can be accomplished either by reversing the armature connections or by reversing the motor field.

With armature reversal, at the instant when it is desired to initiate braking, the grid impulses are phased back to the position for maximum inverter back e.m.f. This interrupts the motor current and the armature connections are then reversed by a reversing switch. The phase position of the converter grid is then advanced to reduce the inverter back e.m.f. to a level that allows braking current to flow. Continuous advance of the grid phase angle will bring the motor to rest and further phase advance will bring the motor up to speed in the reverse direction. This system is being used for the rolling mills in course of construction in the company's Stafford works. If a speed change involves braking and reversal, the switch operates once only. If a speed change involves a lower speed in the same direction of rotation, the switch will have to operate twice.

Using field reversal, the procedure is similar except that the inverter e.m.f. can be reduced to allow braking current to flow as soon as the machine e.m.f. has reversed. The inverter back e.m.f. is controlled at the level that provides the requisite braking current until the motor is at rest. Reverse rotation of the motor is obtained by further advance of the grid phase position.

Armature reversal can be made slightly faster than field reversal. The value of this time advantage depends on the application. Much the same equipment is required for the two systems except that armature reversal involves the use of a relatively heavy current reversing switch which, however, does not break current; it must withstand frequent operation.

English Electric have developed two armature reversing switches. The basis of each is that a set of four electro-pneumatically operated contactors, similar to those used for main line locomotive work, are assembled on a single framework and interlocked so that only the appropriate contactors can close at any given moment. A reversal time, for the switch itself, of one eighth of a second is achieved. A life of at least 5 million and possibly 15 million switching operations is expected. Since the number of passes encountered in most rolling mills is less than 2½ million per annum, and since on most passes the switch would be called on to operate once only, a life of 5 million operations is equivalent to about two years normal use. The smaller switch is suitable for working with reversing motors of up to 1,500 A continuous rating at 750 V, and will handle frequently occurring peak currents of 4,000 A. The larger switch is capable of approximately 5,000 A continuous capacity, a peak of 12,000-15,000 A, and a service voltage of 1,200 V. This corresponds to a motor rating of about 5,000 to 6,000 h.p., so that with two reversing switches a 10,000 to 12,000 h.p. twin drive is possible.



Reversal of the armature switch is delayed until the magnetic amplifier in the switch control circuit detects zero current flow through the armature.

The scheme of control used by the company is a speed control rather than a voltage control. A diagram of the system appears above. The operator's controller provides a reference signal between ± 100 V, which is compared with the voltage of a tachometer driven by the motor. Any difference between the desired and actual speeds is detected by a magnetic amplifier and fed to the circuits controlling the phase of the grid impulses in a way that adjusts the converter voltage to provide the correct motor speed. The grid control unit is of the impulse reactor type.

If the controller is moved from forward to reverse, the speed error signal goes negative, retarding the phase of the grid impulses and stopping the main current through converter and motor. As soon as the magnetic amplifier connected to the switch relay detects the absence of current it causes the armature switch to be reversed. Auxiliary contacts on this then reconnect the error circuit so that the converter starts to reduce its inversion voltage. As soon as the converter voltage matches the motor voltage, inversion current flows and the motor is braked regeneratively, going through zero speed as the converter starts to rectify again. Making the magnetic amplifier connected to the switch

Continuing Design

check that the main current is virtually zero is a useful interlocking feature, as the switch does not then have to break current. A subsidiary loop containing a further magnetic amplifier is connected to the direct current sensor to limit the current in the main circuit to a safe value.

The motor field system provides basically fixed full excitation by means of a conventional current control system. If the controller calls for a speed higher than the converter can provide at its normal voltage, it tries to produce excess voltage. This is detected by the field control circuit and used to initiate field weakening, so that the speed does rise to the required value. Braking from the speeds of field weakening requires field strengthening to maintain maximum braking torque. The same excess voltage control circuit operates in this condition to prevent the motor developing too much voltage as it slows down. This also prevents the converter from having to try to produce too many inverter volts. In reversal from top speed one way to top speed the other way, switch reversal is followed by field strengthening at full inverter volts, then in turn by the converter changing to rectification and by field weakening.

TIME TO REVERSE

On the demonstration equipment, the switch reverses and the current flows again within 0·19 sec of the controller being moved from base speed in one direction to base speed in the other. The end of the reversal occurs 1·96 sec after the beginning of the controller movement. The additional 1·77 sec is determined solely by the current capabilities of the machines. Given suitable machine characteristics, the company consider that 1·5 sec or less would be quite practicable for the total time. In the control sequence, the switch takes 117 millisec from first release of the closed magnet valves until the main direct current circuit is completed in the reverse direction. The rest of the 190 millisec is taken up by the circuitry concerned with the reversing operation.

Demonstrations were also given of field reversal schemes, as they would be applied to mill drives and to mine winders. For the mill drives the same equipment as that already described was used, the armature switch being locked in one position. Field reversal occurred under the same conditions as switch reversal and, in fact, the magnetic amplifiers previously used to control the switch were used to control exciter reversal.

Field reversal was completed and the motor carried current again in about 0·5 sec; the motor reached base speed again in about 2·5 sec. The largest component in the 0·5 sec was the time taken to collapse and re-establish the motor field. This time could be shortened by using a laminated construction for the main motor field.

For the mine winder demonstration a laminated frame machine was available. The 1,600 kW machine used to represent the winder motor was coupled to a generator of identical electrical design but solid frame construction. The main difference in the control circuit compared with the rolling mill control was the inclusion of a rate of change control in the speed reference, to set the acceleration and retardation rates for winder duty cycles. To simulate winder loading the generator coupled to the winder motor was excited with a constant field and the armature current was fed to the four d.c. machines of the previous demonstration, connected in parallel. A generator field exciter supplies the fields of the four machines and operates in conjunction with a current regulator to maintain the armature current in the four machines at a value dictated by a reference signal. The current could be maintained at a constant value equivalent to the constant load torque of a friction winder or balanced drum winder, or it could be varied throughout the wind to represent the changing load torque of an unbalanced drum winder. These two basic types of duty cycle were demonstrated. The demonstration system inertia gave winds which for the simulation of a balanced drum winder approximated to an installation having an r.m.s. rating of 900 h.p., while that for a friction winder approximated to an installation having a rating of 1,500 h.p. In addition to normal duty cycles, the ability of the electrical control to give the low speeds necessary for rope and shaft inspection was demonstrated.

So far as is known, no manufacturer has yet commissioned a scheme of this type for mine equipment. Compared with an a.c. mine winder, the d.c. motor drive fed from a mercury arc converter is more expensive in first cost. Its losses, however, are usually less and it permits the use of d.c. motor characteristics for economic speed control comparable with those offered by the Ward-Leonard system. With underground winders, space considerations and facilities for heat dissipation are of importance and in such circumstances the mercury arc converter shows to advantage.

FIXING RAILS FOR OVERHEAD CRANES

The rails for gantry cranes are frequently carried on steel girders which may take the form of simple or continuous beams. There would seem to be two fundamental ways of fixing the rails to the girder flange —either they are secured so completely that relative movement is impossible and the rail forms virtually an extension of the flange, or the rail may be free to move longitudinally without appreciable build-up of stress in it. The first may be termed the "fully-hard" method and is typified by a welded connection, and the second the "fully-soft," which can be achieved by using spring clips. Two types of spring clip were designed by the Research and Development Department of W. S. Atkins and Partners in 1952 and have been developed in collaboration with Guest, Keen and Nettlefolds Limited. Following static and fatigue laboratory tests and three years limited service experience, the clips were first used on a large scale in a steel mill at the Velindre Works of the Steel Company of Wales. The spring clips are now being marketed by the G.K.N. organisation.

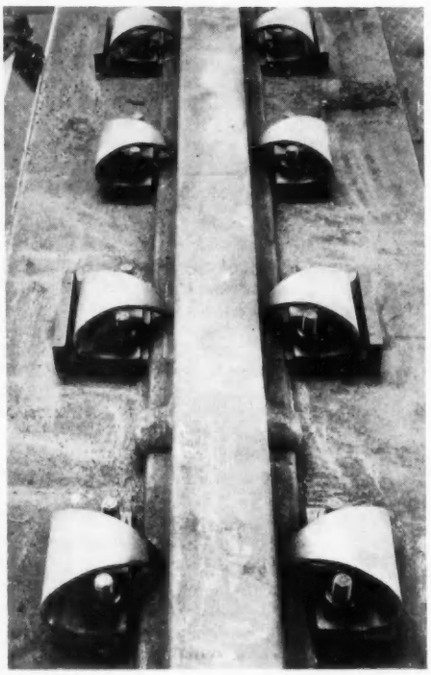


Fig. 1

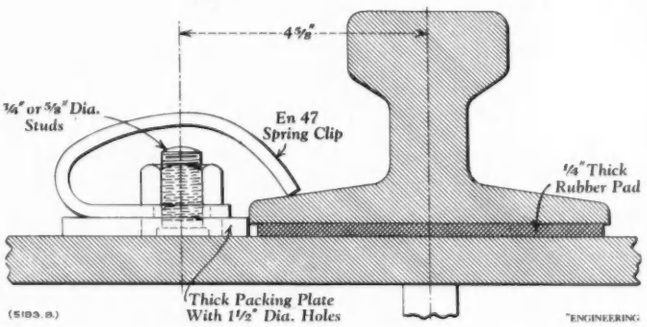


Fig. 2

Gantry crane long-travel track is generally arranged to obtain continuous support on the flat surface of the top flange of a girder which changes in length under load. In contrast, ground track, or railway track, generally has support at chairs and sleepers and spans between these. The ground, however, does not change in length under load and the only longitudinal movement to be accommodated is produced by expansion. This is the essential difference between gantry rail fixing and ground rail fixing and governs the design of any fixing system.

If the system of attachment positively fixes the rail to the girder then, under load, the rail will be subjected to the same longitudinal stress as the girder flange. Hence the fixing devices must transmit the longitudinal shear force which develops between rail and flange. As an example, for a 175 lb per yd rail the cross-sectional area is 16 sq. in and if the stress in the girder flange (and hence the rail) is 5 tons per sq. in, this shear force will be $16 \times 5 = 80$ tons. This is usually called a "fully-hard" solution. Most of this force has to be transferred to the rail over a short length, which, in the case of simply supported girders, occurs at the ends of the span. If the end fastenings in these positions cannot withstand the shear they will fail by loosening and/or fatigue aggravated by fretting corrosion, and will be followed by progressive failure of the fastenings along the span. This "zip fastener" effect is well known to some maintenance engineers. In the case of continuous girders the largest shear occurs at points of contraflexure, the positions of which vary between limits as the crane rolls over the span.

If the fixing system allows the rail to be free in a longitudinal direction, this longitudinal shear force cannot develop but relative movement must take place when the girder flange changes in length under load. On a 50 ft span girder having a mean flange stress of 4 tons per sq. in, the change in length of the flange under load is $\frac{4 \times 50 \times 12}{13{,}000}$, or approximately 0·2 in. Any fixing system which is designed to allow this relative movement to take place is called a "fully-soft" solution.

Under conditions of repeated loading, fatigue becomes an important consideration. The fully-hard solution must be capable of transmitting the shear forces which are developed in combination with the local stresses arising from the inter-action of rail and flange, without suffering from fatigue. Alternatively the fully-soft solution must be capable of withstanding the deflections which will be imposed without failing from fatigue.

As examples of these two systems, the welding of the rail to the flange, or the G.K.N. type 1 spring clip, can be considered as fully-hard solutions, and the G.K.N. type 2 spring clip, illustrated above, as fully-soft. The reason why

welding is not satisfactory is that lack of straightness and flatness of the rail and the girder flange leads to an initial lack of fit with subsequent heavy stresses in the welds beneath the wheel loads, which are repeated every time a loaded wheel passes and which fail by fatigue.

The majority of conventional rail fixing systems lie between the fully-hard and fully-soft solutions. On light duty gantries (i.e., gantries in which the daily number of crane movements is small) not exposed to the weather, fatigue and fretting corrosion are not governing factors and little difficulty is usually experienced. In production shops, however, and all installations in which the cranes have medium or heavy duty, fatigue failures occur, since the fastenings in general can neither resist the shear forces which are produced nor allow relative movement to take place. Systematic failure follows. There is a tendency for the fastenings to work loose and this increases the stress range on the bolts or studs and so accelerates the effects of fatigue. If these bolts were to be kept tight by continual inspection (in the way that railway tracks are inspected) then their life would be considerably longer; frequently, however, this is impracticable.

FULLY-SOFT CLIPS

The type 2 gantry clip is a fully-soft solution which, when tightened, has sufficient resilience to prevent it from working loose, and will allow sufficient relative movement to take place between rail and flange, without suffering from fatigue, to make it suitable for almost all gantry installations. The secondary stresses which are set up in the girder flange through interaction of the rail can, themselves, give rise to fatigue damage of the girder flange when the crane duty is high (that is to say the crane makes a large number of movements each day), particularly when the flanges are relatively thin and lack of fit occurs between the rail and flange. In addition, fretting corrosion takes place at the sliding contact surfaces. These secondary stresses can be reduced by distributing the wheel load from the rail across and along the girder flange. This has been achieved by interposing a suitably designed rubber pad as a " sandwich " between the rail and flange. This technique has been used satisfactorily on a number of installations and the increased range of relative vertical movement which takes place can be accommodated by the spring clips, provided they are pitched at a spacing to maintain contact through the sandwich under all fatigue conditions of loading. The rubber pad has also been found to be successful as an anti-fretting medium on both indoor and open gantries.

The function of the spring clip is to locate the rail on the girder flange. It should prevent longitudinal creep, resist sideways forces and hold the rail in contact with the girder against the effects of the precession wave that moves ahead of each loaded wheel. It is this precession wave which gives rise to variation in bolt load on conventional solid clip fastenings, particularly when these have worked loose.

The choice of spring clip and spacing is governed by several factors including the estimated duty of the crane and its maximum wheel load, the section of the rail to be fixed and whether it is to be welded into continuous lengths, the girder spans and whether they are to be simply supported or fully continuous over the stanchions.

The G.K.N. spring clip is the outcome of an extensive programme of development work. A comprehensive series of fatigue tests has been carried out on spring clips made from En 47 chrome-vanadium spring steel and the fatigue life it gives allows the useful range of the clips to suit most forms of girder. For instance, it will permit the use of the clip for securing continuous crane rails over simply-supported girders, where the relative end-long movements of rail with respect to the flange are greater than with continuous girders. As most existing gantries are of the simply-supported type, a considerable improvement in the running conditions of cranes and a reduction in maintenance troubles can be achieved by replacing existing discontinuous rails by continuous rails and spring clips.

The type 2 spring clip is made generally in three thicknesses, for use on a wide range of gantries. The clips are designed to be used where the crane rail is soft-mounted on a rubber pad, although they will operate successfully without it, and they should be secured by welded studs or mild steel bolts. Correctly tightened, they will never work loose and the bolts or studs will not fail in fatigue. Dimensions and characteristics for the different sizes are given in the accompanying table; the fatigue endurance values for nose movement are for 2 million reversals without failure.

Type	Material and dimensions	Nose deflection, in	Clamping force, tons	Fatigue limit deflections, in girder flange, in	
				Longitudinal	Lateral
2B	En 47 6 in × $\frac{1}{4}$ in	$\frac{1}{8}$ in	0·65	±0·055	±0·030
2B	En 47 6 in × $\frac{5}{16}$ in	$\frac{3}{8}$ in	1·25	±0·040	±0·025
3	En 47 7 in × $\frac{3}{8}$ in	$\frac{7}{8}$ in	1·75	±0·065	±0·040

Type 2B clips can be used on simply-supported spans up to 50 ft (the spacing varying from 30 in to 50 in according to duty) or on continuous spans up to 65 ft. Type 3 is for 375 lb rail and simply-supported spans of 60 ft and continuous spans of 80 ft. Normally, spacing should not exceed 30 in.

The G.K.N. type 1 spring clip operates on a different principle and may be regarded mainly as a fully-hard solution which can allow occasional movement under peak loading conditions. It is a resilient clip designed to give the maximum clamping force per lb weight per pound sterling. It is suitable for light girders (i.e., those on which small and medium sized cranes operate) of light or medium duty and, by taking a realistic value of the coefficient of friction between the rail and the flange, the spacing can be adjusted so that the clips will resist effectively the shear forces present. In addition it can be used on very light duty gantries carrying heavier cranes. When fully tightened the clip exerts a force of 4 tons, corresponding to a nose deflection of $\frac{3}{16}$ in. It is made from flat spring steel, 6 in by $\frac{1}{4}$ in. When correctly used on the lighter girders, this clamping force is sufficient to enable the rail to be stressed with the girder by means of the friction developed between the two under the action of single cranes. With most gantries the maximum flange stresses are developed under two-crane conditions, which occur infrequently, and for these conditions the type 1 clip allows slipping to take place without loss of clamping force. Once again, loosening and fatigue of spring clip and fastenings are unlikely.

TROPOSPHERIC LINK

In recent years, experiments have been carried out by Marconi's Wireless and Telegraph Company Limited on wireless communication by tropospheric scatter propagation. An experimental system between Bromley, Essex, and Catterick, Yorkshire, has been in use for the past two years and has provided the opportunity for the analysis of transmission characteristics. In parallel with this work, a range of tropospheric scatter transmitting and receiving equipment has been designed and is now being put into production in the company's Chelmsford factory.

It is generally supposed that this type of radio propagation arises from the scattering of radio waves by irregularities in the refractive index of the atmosphere. Irregularities are caused by fluctuations of pressure, temperature, and water vapour content, resulting from atmospheric turbulence, which is probably always present to some extent in the troposphere and lower stratosphere. Star twinkle is another way in which the refractive index variations manifest themselves. Propagation by tropospheric scatter can lead to interference in the reception of television programmes; signals from Continental stations which are normally too weak to be received can be enhanced by this mechanism until they cause difficulties in the reception of local programmes.

The transmitter and aerial are at Start Point one end of a 200 mile radio link using tropospheric scatter propagation.

The first Marconi production units have been assembled as a multichannel link between Start Point, Devon, and Galleywood, Essex, a distance of just over 200 miles. A working frequency of 858 Mc/s has been chosen and the initial capacity of the system is 60 telephone channels. However, features are provided that will subsequently permit experimental wide-band transmissions, with a view to carrying a much greater number of channels. Later, television pictures are also to be transmitted over the link to find out if an acceptable quality can be realised.

The Start Point transmitter employs a water-cooled four-cavity klystron developing an output power of 10 kW. The aerial system—a 30 ft diameter paraboloid excited by a horn radiator—stands with its centre 35 ft above ground level. A gain of 36 dB over a dipole at the working frequency is obtained. Thus the effective radiated power in the direction of maximum intensity is of the order of 40 MW.

The receiving equipment at Galleywood is of the dual-diversity type. It employs two dish aerials, each of 30 ft diameter, spaced 100 ft apart. Previous experience has shown that this method does much to counteract the rapid signal fading characteristic of tropospheric scatter working.

The company consider that such links can satisfactorily provide point-to-point transmission of signals over a distance of 200 miles or more. This is to be compared with the 40 mile average of direct-beam systems. Although in some cases it may be more expensive, the tropospheric scatter method can be used over routes where intermediate repeater stations are impracticable, as over deserts or long expanses of water.

Tropospheric scatter links are used for parts of the " White Alice " system of communications under construction for United States forces in Alaska. The whole system uses both line-of-

Continuing Design

sight microwave links and scatter links to connect about 33 U.S.A.F. sites. Frequencies between 700 and 1,000 Mc/s are used for scatter stations, with powers of 10 kW. Another tropospheric scatter link exists between Florida and Cuba; it is said to be suitable for carrying a television channel plus 120 telephone channels. Reflectors with 60 ft aperture are used, spaced 200 ft apart. In addition to the space diversity provided by the two aerials, frequency diversity is introduced by sending the same information at slightly different frequencies. The result is a quadruple-diversity system.

VENTILATED MEAT WAGONS

The first of 70 British-gauge Interfrigo meat wagons to be fitted with electrical ventilation are now in traffic on British Railways for the through conveyance of carcase meat from Britain to the Continent via the Harwich-Zeebrugge and Dover-Dunkirk train ferries. All 70 wagons are to be fitted with electric ventilation by September this year.

The use of this electric system provides for greatly improved ventilation, particularly at low speeds; allows perishable foodstuffs to be refrigerated before dispatch; and by the elimination of the overhead ducts used in air-operated equipment, gives headroom for the carriage of larger quarters of meat.

The equipment consists of four ventilation fans, each driven by a single-phase condenser motor, built into screens, two at each end of the vehicle. The four motors obtain electric current from a belt-driven permanent-magnet alternator with bi-phase windings, of which each phase supplies two motors. Protection fuses for the electrical circuits, alternators, and the four motor condensers, are housed in an external casing at one end of the wagon.

An " on-off " lever control for the ventilation system—sealed in the " on " position when the van is loaded—is fitted at each side of the wagon. The operation of the equipment may be checked before loading by rotating an adjacent crank handle.

Refrigeration of the contents before dispatch is carried out after icing and loading the wagon, by connecting the fan motors to the mains supply through a special plug-adaptor. The capacity of these four-wheel vehicles is 1,095 cu. ft.

INVENTORS' INFORMATION SERVICE

For the private inventor who has not at his disposal the services of a patent department, it is a time-consuming process to keep track of all new developments related to his field; but if he does not do so, he runs the risk of wasting valuable effort on an invention that has already been exploited—or he may remain unaware that some patent of his own is being infringed. With these points in mind, a regular patent advisory service has been introduced recently, which offers, for an annual fee of 5 guineas, to keep the client informed on developments in his own field. Details may be obtained from Captain T. A. Hampton, British Underwater Centre, Warfleet, Dartmouth, Devon.

Engineering at Home

VENTILATION AND AIR CONDITIONING

The British Standard Code of Practice for Mechanical Ventilation and Air Conditioning in Buildings (C.P. 352: 1958) has recently been published. It is one of a series of codes prepared by a committee convened by the Institution of Mechanical Engineers and the Institution of Heating and Ventilating Engineers on behalf of the former Council for Codes of Practice for Buildings. The booklet is intended as a guide to modern practice in designing, planning, installing, testing, and maintaining mechanical ventilating and air conditioning plant. Application of the code does not, however, confer immunity from statutory requirements in local government byelaws or from the special regulations of utility supply companies.

The code states that ventilation is necessary for any of the following reasons:

a. To prevent an undue concentration of body odours, fumes, dust and other industrial products.

b. To prevent an undue concentration of bacteria-carrying particles.

c. To remove products of combustion and, in some cases, to remove body heat and the heat produced by electrical and mechanical equipment. Where heat gain or solar radiation is excessive, air conditioning should be considered.

d. To create air movement.

e. To prevent an undue accumulation of carbon dioxide and moisture, a depletion of the oxygen content of the air.

f. To maintain conditions suitable to the contents of the space.

g. To prevent flammable concentrations of gas vapour or dust.

Air conditioning is necessary, says the code, for reasons *a* to *g* inclusive, together with the following:

h. To control within predetermined limits the temperature and humidity inside the building irrespective of the material heat gains, or the outside atmospheric conditions. Tables give fresh-air requirements, on a basis of body-odour concentration, and the air changes per hour for different types of building. For the purposes of the code, the " rate of fresh air change " is the ratio of fresh air applied every hour to the volume of the enclosed space.

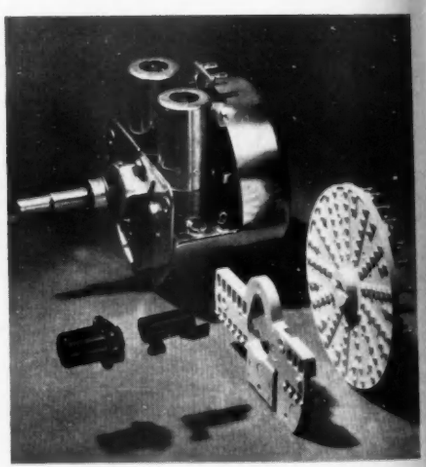
The head-code deals with general matters such as time schedules, district surveyors' or local authorities' fees, design, inspection, and maintenance. Emphasis is placed on the need for close liaison with the various contracting parties at the planning stage, and on the importance of maintaining a strict time schedule. Eight sub-codes treat the following subjects: fans, motors and starting gear; air heaters; air distribution system; air cleaning devices; thermal insulation; sound-proofing and anti-vibration devices; temperature and humidity controls; cooling and dehumidification. The text is amplified by ten diagrams and charts. Copies of the code (price 20*s.*) can be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1.

TURRET TUNER PLASTICS

The heart of a new television tuner produced by A.E. Metal Products Limited, Abercynon, Glamorganshire, is a circular plate moulded from Bakelite alkyd DX.18926. Through it are mounted 104 metal pins, which the selector coils lie between. On the reverse side the pin heads are arranged radially in sixes and pairs to mate with the selector arm, moulded from the same alkyd and carrying eight metal contacts. A feature of the plastics disc, apart from its electrical stability and resistance to heat, is its intrinsic toughness necessary for the insertion of the 104 pins.

The " Fireball," as the tuner is called, is claimed to be the first British tuner with 13 channels, and to be less than a third the size of earlier turret tuners. It is 2 in deep and has a diameter a fraction over 3 in. The complete assembly, with valves, is shown in the illustration, together with the four plastics parts used.

The two further plastics components are made of phenolic black X.17165, produced by Bakelite Limited. They form the fine adjustment mechanism of the tuner. The first moulding is a collar, bearing a cam-shaped rear face, rigidly fixed to the outer " fine tuning " spindle. The second is a spring-loaded ferrule carrying two teeth, one of which bears on the cam surface of the first moulding causing it to move in and out of the tuner by rotation of the spindle, while the second tooth engages with the moving plate of a book condenser, to give the fine adjustment to the tuning circuit.



A plastics moulding carrying 104 pins is embodied in the turret tuner. The plastics must not only have good electrical characteristics but must also be tough.

Based on an American patent, the circuits, selectors and other components have been designed for British television. Thirteen channels are the maximum number so far announced. At present nine are in daily use.

ENGINEERING

Published every Friday by ENGINEERING LTD. at 36 Bedford-street, London, W.C.2.
Telephone: Temple Bar 3663.
Telegrams: Engineering Lesquare London.

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